Canada. [Boundary commissions]
Manitoba - Northwest Territories boundary
commission.

Report - -

Commissioners

R. THISTLETHWAITE, D.L.S., A.L.S., B.C.L.S., Surveyor General
For the Government of Canada.

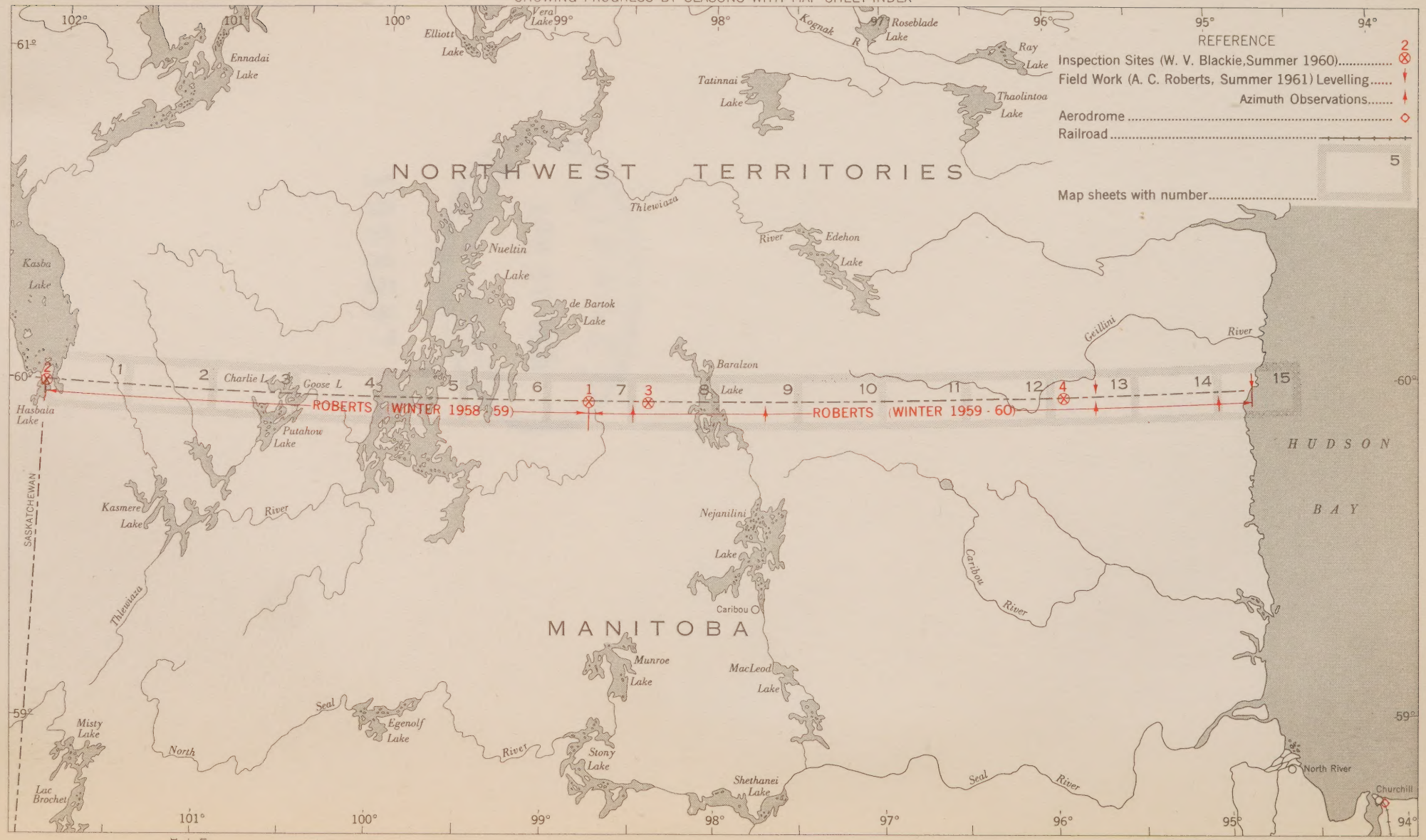
E. GAUER, D.L.S., M.L.S., Director of Surveys
For the Government of Manitoba.

Report of the Commission Appointed to Demarcate the Boundary between the Province of Manitoba and the Northwest Territories

Manitoba-Northwest Territories Boundary
Commission
1964

KEY MAP

SHOWING PROGRESS BY SEASONS WITH MAP SHEET INDEX



PRODUCED BY THE SURVEYS AND MAPPING BRANCH, OTTAWA.

OTTAWA, ONTARIO,

August 2, 1965.

TO THE HONOURABLE J. WATSON MACNAUGHT, P.C., Q.C., M.P., MINISTER OF MINES AND TECHNICAL SURVEYS, OTTAWA, CANADA; THE HONOURABLE STERLING R. LYON, Q.C., M.L.A., MINISTER OF MINES AND NATURAL RESOURCES, WINNIPEG, MANITOBA.

Your Commissioners, R. Thistlethwaite, D.L.S., A.L.S., B.C.L.S., representing the Government of Canada, and E. Gauer, D.L.S., M.L.S., representing the Government of Manitoba, have the honour to submit the following report on the survey of the Manitoba-Northwest Territories Boundary performed during the years 1959 to 1962, inclusive.

The survey field work was done by the following surveyors:

Latitude Observations—

G. A. Corcoran, D.L.S.,	1957

Demarcation—

A. C. Roberts, M.L.S.	1959, 1960 and 1961
L. E. Boutilier, M.L.S.,	1962.

Accompanying this report is an atlas of 15 map sheets, covering the entire boundary.

R. THISTLETHWAITE
E. GAUER
} *Commissioners*

Available by mail from the Queen's Printer, Ottawa,
and at the following Canadian Government bookshops:

OTTAWA
Daly Building, Corner Mackenzie and Rideau

TORONTO
Mackenzie Building, 36 Adelaide St. East

MONTREAL
Æterna-Vie Building, 1182 St. Catherine St. West

WINNIPEG
Mall Center Bldg., 499 Portage Avenue

VANCOUVER
657 Granville Avenue

or through your bookseller

A deposit copy of this publication is also available
for reference in public libraries across Canada

Price $2.00 Catalogue No. M59-1165

Price subject to change without notice

ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1965

CONTENTS

Chapter		Page
I	Introduction	1
	Statutory Description of Boundary	1
	Antecedents	2
	Orders in Council Establishing Commission	2
II	Prescribed Methods of Survey	7
III	Survey Operations	13
	Astronomic Latitude Determination, Summer 1957	13
	Demarcation Surveys	14
	Field Operations – Winter 1958–59	14
	Field Operations – Winter 1959–60	25
	Field Operations – September 1961	35
	Completion of the Boundary – April 1962	37
IV	Verification of Field Work	39
	Examination of Survey Records	39
	Field Inspection	39
	Random Comparisons	42
V	Conclusion and Recommendations	43
	Summary of Survey Results	43
	Recommendations	43
	Disposition of Survey Records	44
	Acknowledgements	44
Appendix I – Latitude Observations		45
Appendix II – Summary of Monument Data		46
Appendix III – General Description of Country		51
Appendix IV – Special Monument at Northwest Corner of Manitoba		53
Appendix V – Photographs of Typical Monuments		55

LIST OF ILLUSTRATIONS

PAGE

Moving camp with an Otter aircraft 15
Hauling firewood to camp with Eliason motor toboggan 15
Transport to and from work by aircraft 15
Camp No. 4 on sheltered northwest shore of lake 17
Office tent with radio and portable desk 17
A forward station—using red and orange plastic targets for line production 19
Chaining to Monument 5 20
Diagram showing rock post and stone mound 22
Constructing a mound from blasted rock 23
Typical bench mark 23
Looking south along esker near Monument 49 23
Typical bare, boulder-covered hill. Tellurometer station A24 in background 24
Tractor train ready to leave Churchill, January, 1960 27
D6 Caterpillar tractor with slipped track on move from Churchill to start of survey, second season 28
Difficulties in deep snow 29
Replenishing fuel supplies by DC3 aircraft on runway prepared by tractors, on lake in barren lands 29
Inside office caboose showing 100-watt transmitter-receiver and portable short-wave radio 30
Camp during a blizzard 30
After a blizzard; snowdrift in the lee of a caboose 30
Sunshade used while observing 32
Free plumb-bob method of chaining 32
Typical view of boulder-strewn barren lands 36
Sketch of monument at northwest corner of Manitoba 53
Photo of monument at northwest corner of Manitoba, looking south 54
Monument 8
Monument 24
Monument 29
Monument 77 — Typical monuments with rock mounds 55
Monument 121
Monument 169 — Typical monuments with rock mounds 56
Monument 171—Terminal monument on shore of Hudson Bay 56

CHAPTER I

INTRODUCTION

Statutory Description of Boundary

By the Manitoba Boundaries Extension Act, 2 George V, Chapter 32, assented to by the province and effective on and after 15th May, 1912, the boundaries of that province became extended by clause 3 as follows:

"3. The limits of the province are hereby increased so that the boundaries of the province shall be as follows: Commencing where the sixtieth parallel of north latitude intersects the western shore of Hudson Bay; thence westerly along the said parallel of latitude to the northeast corner of the province of Saskatchewan; thence southerly along the easterly boundary of the province of Saskatchewan to the international boundary dividing Canada from the United States; . . . thence westerly and northerly following the shores of the said Bay to the point of commencement; and all the land embraced by the said description not now within the province of Manitoba, shall, from and after the commencement of this Act, be added thereto and the whole shall, from and after the said commencement, form and be the province of Manitoba."

The portion of the Northwest Territories lying north of Manitoba, known as The Provisional District of Keewatin, is described in Order in Council P.C. 655, dated March 16, 1918, as follows:

"Commencing at the point where the second meridian in the system of Dominion land surveys as the same may be hereafter defined in accordance with the said system intersects the continental shore of the Arctic Ocean; thence easterly along the said shore to the most northeasterly point of Spence Bay; . . . thence northerly following the western shore of James Bay to Hudson Bay; thence westerly following the southern shore of Hudson Bay to the point where it is intersected by the boundary between the provinces of Ontario and Manitoba; thence northwesterly following the southern shore of Hudson Bay to the point where it is intersected by the parallel of the sixtieth degree of north latitude; thence westerly along the said parallel to the second meridian in the system of Dominion land surveys as the same may be hereafter defined in accordance with the said system thence northerly along the said meridian to the point of beginning."

Since the province of Manitoba is described above as being bounded by the "easterly boundary of the province of Saskatchewan", it is necessary to consult the statutory description of the latter province in order to interpret the description. This is contained in the Saskatchewan Act, 4-5 Edward VII, Chapter 42, assented to 20th July, 1905, and is as follows:

"Commencing at the intersection of the international boundary dividing Canada from the United States of America by the west boundary of the province of Manitoba, thence northerly along the said west boundary of the province of Manitoba to the northwest corner of the said province of Manitoba; thence continuing northerly along the centre of the road allowance between the twenty-ninth and thirtieth ranges west of the principal meridian in the system of Dominion land surveys, as the said road allowance may hereafter be defined in accordance with the said system, to the second meridian in the said system of Dominion land surveys, as the same may hereafter be defined in accordance with the said system; thence northerly along the said second meridian to the sixtieth degree of north latitude; . . . thence easterly along the said international boundary to the point of commencement, is hereby established as a province of the Dominion of Canada, to be called and known as the province of Saskatchewan."

Antecedents

A few years after the end of World War II there was a marked trend northward in the exploration and development of mineral resources, including oil and gas, in the northern portions of the western provinces and extending across the sixtieth parallel of latitude into the Northwest Territories.

This parallel of latitude forms the northern boundary of these provinces and to provide for the proper administration and development of the natural resources, it was deemed advisable to make the surveys necessary to mark the boundary.

By 1954, the survey of the Alberta-Northwest Territories boundary had been completed and in the following year a start was made on the survey of the Saskatchewan-Northwest Territories boundary.

Early in 1955, with the above facts in mind, the Deputy Minister of the Department of Northern Affairs and National Resources suggested to the Deputy Minister of the Department of Mines and Natural Resources of the Province of Manitoba that the time was appropriate to consider the formation of a Manitoba-Northwest Territories Boundary Commission for the purpose of delineating on the ground the boundary between Manitoba and the Northwest Territories.

At that time, the nearest mining activity in Manitoba was at Seal River, about 80 miles south of the boundary and the nearest in the Northwest Territories was at Eskimo Point, about 70 miles north of the boundary.

Because certain astronomic and other preliminary work would have to be done before the demarcation survey could be commenced, it was agreed that the formation of the Commission at this time was desirable. Accordingly, Commissioners were appointed and the Manitoba-Northwest Territories Boundary Commission was established by federal and provincial Orders in Council as quoted below.

Orders in Council Establishing Commission

Copy of a Minute of a Meeting of the Committee of the Privy Council, approved by His Excellency the Administrator on the 7th of July, 1955.
P.C. 1955–1014

The Committee of the Privy Council have had before them a report dated June 15, 1955, from the Minister of Mines and Technical Surveys, representing:

That the boundary line between the Province of Manitoba and the Northwest Territories, defined as the parallel of the sixtieth degree of north latitude commencing where the sixtieth parallel intersects the western shore of Hudson Bay, thence westerly along the said parallel of latitude to the northeast corner of the Province of Saskatchewan, by the Manitoba Boundaries Extension Act, 1912, has not been surveyed and marked on the ground;

That it is desirable that the survey and demarcation of this boundary line be completed as soon as possible in order to define the limits of federal and provincial jurisdiction for administrative purposes;

That it would be desirable to set up a Commission so that preliminary work could be undertaken for the eventual survey of the boundary;
and

That the Government of the Province of Manitoba has agreed to the establishment of such a Boundary Commission, with the understanding that expenses will be shared equally between the Government of Canada and the Province of Manitoba.

The Committee, therefore, on the recommendation of the Minister of Mines and Technical Surveys, advise that a Commission be established, to be known as the Manitoba-Northwest Territories Boundary Commission, consisting of R. Thistlethwaite, Esquire, Surveyor General of Canada, who shall be Chairman, and H. E. Beresford, Esquire, Director of Surveys of the Department of Mines and Natural Resources of the Province of Manitoba, with authority to issue instructions for and direct the execution of all necessary surveys, including the employment of all professional and other personnel, and the purchase of equipment and supplies required to make the survey of the boundary line between the Province of Manitoba and the Northwest Territories, and to accept in their discretion previous fixations of boundary points where these points are of the desired accuracy, Canada to pay one half the cost incurred by the Commission, to be chargeable to Appropriations to be provided: the report of the said survey to be submitted by the said Manitoba-Northwest Territories Boundary Commission to the Parliament of Canada and the Legislature of the Province of Manitoba.

"R. B. Bryce."
Clerk of the Privy Council.

Copy of Order No. 469/40 of the Lieutenant-Governor-in-Council approved and ordered by His Honour the Lieutenant-Governor on April 24th, 1940.

The Honourable the Minister of Mines and Natural Resources submits to Council a report setting forth:

Whereas by Order in Council No. 567/31, dated May 9th, 1931, Samuel E. McColl, Director of Surveys in the Department of Mines and Natural Resources, was appointed Interprovincial Boundary Commissioner and was authorized to represent the Province of Manitoba on all matters whatsoever and wheresoever arising in respect to the delimiting of the boundaries of the Province;

And whereas the said Samuel E. McColl died on the 26th day of January, 1940;

And whereas by Order in Council No. 169/40, Henry E. Beresford was appointed Director of Surveys in the place and stead of the said Samuel E. McColl;

And whereas it is advisable that the said Henry E. Beresford be appointed Interprovincial Boundary Commissioner and authorized to represent the Province of Manitoba on all matters whatsoever and wheresoever arising in respect to the delimiting of the boundaries of the Province;

On the recommendation of the Honourable the Minister, Committee advise—

That the said Henry E. Beresford, Director of Surveys in the Department of Mines and Natural Resources, be and he is hereby appointed Interprovincial Boundary Commissioner and is hereby authorized to represent the Province of Manitoba on all matters whatsoever and wheresoever arising in respect to the delimiting of the boundaries of the Province.

"P. A. Talbot."
Clerk, Executive Council.

Winnipeg, Manitoba,
April 19th, 1940.

(*The Honourable Mr. Bracken in the Chair*).

Copy of Order No. 1061/59 of the Lieutenant-Governor-in-Council approved and ordered by His Honour the Lieutenant-Governor on August 4th, 1959.

The Honourable the Minister of Mines and Natural Resources having submitted to Council a report setting forth that:

Whereas by Order in Council No. 469/40, dated April 24th, 1940, Henry E. Beresford, Director of Surveys in the Department of Mines and Natural Resources, was appointed Interprovincial Boundary Commissioner and was authorized to represent the Province of Manitoba on all matters whatsoever and wheresoever arising in respect to the delimiting of the boundaries of the Province;

And whereas the said Henry E. Beresford was retired as Director of Surveys on the 31st day of July, 1959;

And whereas by Order in Council No. 1010/59, Edward Gauer was appointed Director of Surveys in the place and stead of the said Henry E. Beresford;

And whereas it is advisable that the said Edward Gauer be appointed Interprovincial Boundary Commissioner and authorized to represent the Province of Manitoba on all matters whatsoever and wheresoever arising in respect to the delimiting of the boundaries of the Province;

Therefore, he, the Minister, recommends:

That Edward Gauer, Director of Surveys in the Department of Mines and Natural Resources, be and he is hereby appointed Interprovincial Boundary Commissioner and is hereby authorized to represent the Province of Manitoba on all matters whatsoever and wheresoever arising in respect to the delimiting of the boundaries of the Province;

That Order in Council No. 469/40, dated April 24th, 1940, be rescinded;

And, upon consideration of the said report and recommendation on the 1st day of August, A.D., 1959 (the Honourable Mr. Roblin in the Chair), Council having advised that it be done as recommended by the Honourable the Minister of Mines and Natural Resources, His Honour the Lieutenant-Governor-in-Council was pleased to approve the said report and recommendation and to order that it be done accordingly.

"Derek Bedson,"
Clerk, Executive Council.

Copy of a Minute of a Meeting of the Committee of the Privy Council, approved by His Excellency, the Governor-General on the 2nd of May, 1963.
P.C. 1963–684

The Committee of the Privy Council have had before them a report dated 1st April, 1963, from the Minister of Mines and Technical Surveys, submitting:

That Order in Council P.C. 1955–1014 of 7th July, 1955, authorized the establishment of the Manitoba-Northwest Territories Boundary Commission consisting of R. Thistlethwaite, Esquire, Surveyor General of Canada and H. E. Beresford, Esquire, Director of Surveys of the Department of Mines and Natural Resources of the Province of Manitoba, to mark on the ground the boundary line between the Province of Manitoba and the Northwest Territories, which boundary line was defined by the Manitoba Boundaries Extension Act, 1912, as the parallel of the sixtieth degree of north latitude commencing where the sixtieth parallel intersects the western shore of Hudson Bay, thence westerly along the said parallel of latitude to the northeast corner of the Province of Saskatchewan;

That Mr. Edward Gauer replaced Mr. H. E. Beresford as Director of Surveys of the Department of Mines and Natural Resources of the Province of Manitoba; the said Edward Gauer was also appointed Interprovincial Boundary Commissioner for the Province with authority to represent the Province on all matters whatsoever and wheresoever arising in respect to the delimiting of the boundaries of the said Province;

That the Commission has not yet completed the work with regard to the boundary line between the Province of Manitoba and the Northwest Territories;
and

That it is considered desirable that a new Commission having the same powers and authority as the Commission established pursuant to Order in Council P.C. 1955–1014 of 7th July, 1955, be established to complete the said work and to report thereon.

The Committee, therefore, on the recommendation of the Minister of Mines and Technical Surveys, advise that a new Manitoba-Northwest Territories Boundary Commission consisting of R. Thistlethwaite, Esquire, Surveyor General of Canada, who shall be Chairman, and Edward Gauer Esquire, Director of Surveys of the Department of Mines and Natural Resources of the Province of Manitoba, in substitution for and to continue the work begun by the Manitoba-Northwest Territories Boundary Commission established pursuant to Order in Council P.C. 1955–1014 of 7th July, 1955

The Committee further advise:

1. That the said Commission be empowered to issue instructions for and direct the execution of all necessary surveys, including the employment of all professional and other personnel, and the purchase of all equipment and supplies required to continue the survey of the boundary line between the Province of Manitoba and the Northwest Territories, and to accept in its discretion previous fixations of boundary points where the points are of the desired accuracy
2. That a report of the said survey be submitted by the said Commission to the Parliament of Canada and the Legislature of the Province of Manitoba;
3. That the costs of the work to be undertaken by the said Commission be shared equally by the Government of Canada and the Government of the Province of Manitoba, the costs to be incurred by Canada to be chargeable to appropriations to be provided.

"R. B. Bryce."
Clerk of the Privy Council

CHAPTER II

PRESCRIBED METHODS OF SURVEY

The methods of survey adopted by the Commission differed in certain details from those used in the demarcation of the boundaries between Alberta and the Northwest Territories and Saskatchewan and the Northwest Territories.

At the first meeting of the Commission early in 1956, the Commissioners discussed an alternative method of surveying the boundary. The purpose of this was to eliminate the expense of running trial lines between astrofixes* before establishing the final boundary.

It was agreed to investigate the possibility of adopting as the boundary the mathematical sixtieth parallel of latitude defined only by an astrofix at the westerly end, thus dispensing with further astronomic control and the survey of trial lines. The boundary could then be surveyed in a manner similar to that of a Dominion Lands Surveys base line in which a continuous series of six-mile (486 chain) chords is marked on the ground with the same theoretic deflection made at all chord terminals to keep them on the mathematically defined parallel of latitude.

After careful study and discussion with various competent persons, the Commissioners resolved that the proposed method would be quite justified and that time and costs for the survey could be considerably reduced.

They felt, however, that prior discussion with the authorities representing ownership on either side of the boundary was needed before making their final decision.

Accordingly, in June 1956, the Commissioner for Canada made a submission through the Deputy Minister of Mines and Technical Surveys to the Deputy Minister of Northern Affairs and National Resources, whose department is charged with administration and control of lands in the Northwest Territories, to determine whether that department would support the Boundary Commission if it resolved to use the more economical method of survey. A similar submission was made by the Commissioner for Manitoba to the Deputy Minister of Mines and Natural Resources, Manitoba. The following is an extract from the first submission:

"Heretofore the term 'parallel of latitude' used in legislation or treaties describing boundaries has been taken to mean 'parallel of astronomic latitude'. In unsurveyed territory, this is the only practical interpretation.

"In practice, the astronomic parallel has been located at intervals by star observations. In between, the parallel has been traced out as a line of uniform theoretic curvature by ground survey. This is a compromise to reduce the expected high cost of very numerous astronomic observations.

"Due to anomalous gravity conditions, the exact linear ground relationship between any two astrofixes is unpredictable. The surveyor's first problem is to determine this relationship by means of a trial survey. Having done so, he is then able to trace out and monument a uniform curve between them, to be accepted as the required boundary. It follows that the survey party must cover the same ground twice and usually cut out two lines through the woods.

*Points whose geographical positions have been determined by precise astronomic observations.

"It is expected that the northern boundary of Saskatchewan will be located to the northeast corner within two field seasons. The proposal now being considered is (once this is done) to simply extend the parallel eastward across Manitoba as a uniform line of constant theoretic curvature, by ground survey.

"In this way, the cost of astrofixes as well as the cost of running trial lines would be saved.

"The practical effect, in terms of area allocated to either administration, cannot be predicted. It is expected, however, that the local differences would compensate and that the overall effect would be negligible. A good deal of precise survey work would be necessary to demonstrate the difference.

"On the other hand, a certain flexibility regarding order of execution of the survey would be sacrificed. Using the present method, portions of the boundary can be established piecemeal, in any required order. The proposed method would enforce running from west to east, consecutively.

"The proposal represents an appreciable departure from precedent, insofar as parallels of latitude are concerned. However, there is a previous case which tends to support it.

"The British Columbia-Alberta boundary is defined, in part, as the 120th meridian. It was traced on the ground as a line running due north from an accepted position near the south end of the meridian portion. No intermediate astrofixes were made to ensure that the boundary was at longitude 120° everywhere. The boundary, as run, has been accepted by all parties, regardless. The method now being considered is analogous to this."

In due course, replies to the submission were received from both departments indicating approval of the proposed method of surveying the boundary. The Commissioners therefore decided to proceed accordingly.

The adoption of this new method allowed the survey to be made without extensive astronomic control but the Commission decided that for the purpose of comparison and substantiation it would be desirable to have one additional astrofix near the mid-point of the boundary and one near Hudson Bay.

There was already an astrofix suitable for this purpose at Hudson Bay for, in 1929, the Geodetic Survey of Canada had assigned C. H. Ney, D.L.S., to establish the intersection of the sixtieth parallel of astronomic latitude with the west coast of Hudson Bay. In July of that year Mr. Ney made the necessary astronomic observations and erected a reference monument and stone cairn to mark the position of the parallel. A copy of Mr. Ney's sketch of this work is reproduced in Appendix I.

Early in 1957, the survey of the Saskatchewan-Northwest Territories boundary had reached the point where further astronomic work was needed to allow it to be continued. The Geodetic Survey was to make the necessary astrofixes to complete the control for that boundary in the summer of 1957, and the most easterly of these astrofixes would also serve as control for the starting point of the Manitoba-Northwest Territories boundary. The Commission decided that the additional astrofix at the mid-point of the boundary could well be undertaken in conjunction with this work and the Geodetic Survey agreed to include this additional observation in its 1957 field work.

The following are extracts from the specifications for this astronomic work:

"Each position to be fixed by not less than 40 pairs of stars observed by Talcott's method over two or more nights and to have a probable error not exceeding 0.10 seconds of arc. (10 feet).

"Each observation should be selected as closely as possible to the 60th parallel and should not be more than 20 chains from it, except under very adverse conditions. To facilitate further survey

operations, points should not be adjacent to an abrupt rise in the ground immediately to the north or to the south.

"Since the observation points may be used to control topographical mapping from vertical air photographs, longitudes should be observed at each point. Longitudes should be determined within an accuracy of about one second of arc. (50 feet)."

The survey of the Saskatchewan-Northwest Territories boundary was completed early in 1958, and the Commission decided to start the survey of the Manitoba-Northwest Territories boundary during the winter of 1958–59. The completion of the Saskatchewan survey also allowed the Commission to compare the spheroidal* latitude of the terminal point with that of many other astronomically determined points along the parallel. This showed the terminal to be within about one-half second of the spheroidal latitude of the mean position of astronomic 60°N as determined by 31 astrofixes spread across the north boundaries of Alberta and Saskatchewan. As individual astrofixes deviated from this mean by as much as four seconds, the terminal represented a very reasonable average point from which to start the Manitoba survey.

Winter Seasons (1958–59, 1959–60)

The following is a summary of the instructions issued by the Commission for the demarcation survey:

The Saskatchewan-Northwest Territories boundary has been surveyed as far easterly as Monument 191 which is situated about 9 chains westerly of the estimated position of the Manitoba-Saskatchewan boundary. The latter boundary has not yet been surveyed in this vicinity so it is not possible at this stage to mark the mutual corner of Manitoba and Saskatchewan. The first monument on the survey of the Manitoba-Northwest Territories boundary should therefore be placed one-half mile easterly of Monument 191 so that the mutual corner may eventually be found by producing the common boundary to an intersection with the line joining the two monuments already in place.

Method of Survey

For the purpose of this survey, the sixtieth parallel of north latitude is to be interpreted to mean a curve having the same curvature as the spheroid (Clarke 1866) parallel of 60° north latitude and passing through Monument 191. While geographic position determinations have been made astronomically at Baralzon Lake and the west coast of Hudson Bay, these are not to affect the positioning of the boundary but are to be tied in to the survey.

A continuous series of 486 chain chords, following in principle the same method as for a base line of the Dominion Lands Surveys system, shall be surveyed easterly from Monument 191. Boundary monuments shall be placed at the terminal points of each chord. Between terminal points, intermediate monuments shall be placed on the chords at intervals of one to one and a half miles. Adjacent monuments shall be intervisible.

In case any of the terminal points of the six-mile chords prove to be unsuitable as a site for a monument, the monument shall be placed at the nearest suitable site on one of the adjacent final chords and the point of deflection shall not be marked. The short final chord formed by this process shall be cleared out and blazed as for other sections of the boundary and shall be taken to be the boundary despite the fact that it will lie slightly to the north of the theoretic point of deflection.

*For calculating control and for mapping, the sea-level surface of the earth is assumed to be an oblate spheroid. In North America the dimensions adopted for this spheroid are those determined by A. R. Clarke in 1866.

The boundary shall be taken to be the straight line joining adjacent monuments.

The boundary shall be well cut out to give a good sky line of about six feet and shall be well blazed.

Azimuths

The azimuths shall be obtained by periodic precise astronomical observations on Polaris. Since the north-south position of the boundary will be mainly dependent upon maintenance of correct azimuth, *particular emphasis should be placed on this aspect of the operation.* At least one set of three acceptable observations should be made on each 486-chain chord. The azimuth of the boundary should be kept theoretic within a tolerance of 15 seconds arc.

Ground alignment of the chord being surveyed should be adjusted after each observation either to correct indicated divergences from theoretic or to compensate for known previous divergences, or both.

The probable error of the mean of any set of observations should be less than 1.5 seconds of arc, where:

$$\text{Probable error} = \tfrac{2}{3}\sqrt{\frac{\Sigma v^2}{n(n-1)}}$$

v=residual of each individual observation

n=number of observations in the set from which the mean is derived.

If the probable error of the mean of the set is more than 1.5 seconds, further observations should be made until the probable error of the grand mean is reduced to the required limit.

Particular attention should be paid to the determination of local sidereal time for these observations, and it is recommended that at least two sidereal watches be maintained in continuous running condition throughout the project.

Chainage

Each portion of the boundary, as well as all surveyed connections to astronomic fixes, offsets or other necessary distances shall be measured by two independent equally careful measurements, one in chains, the other in feet. The mean of the two measurements shall be taken as the dimension to be accepted. The discrepancy between them should not exceed one part in thirteen thousand, two hundred. Account is to be taken of slope, temperature, sag, stretch and tape corrections. Slopes exceeding four degrees must be measured by a transit. All tapes used are to be certified as to length by the National Research Council. No tape that has been broken and subsequently repaired may be used if the break is within the measuring part of the tape.

If the nature of the terrain is broken, it will be necessary to use the tripod chaining method with intermediate support for the chains. If the country is flat, a simpler method of chaining may be adopted, provided the specified tolerance is met.

Where triangulation is necessary to cross water or other obstacles, the necessary distances are to be obtained by double triangulation, in accordance with the Manual of Instructions for the Survey of Dominion Lands.

Monuments

Permanent monuments are to be erected on the boundary at intervisible points. An interval of about one to one and a half miles is suitable; it should never exceed three miles. A number of special boundary rock posts, similar to the D.L.S. short standard posts, have been provided for the survey. The posts are inscribed for Manitoba and the Northwest Territories and the number of the monument and the year of the survey are to be stamped upon each post, upon placement. The monuments are to be numbered consecutively from one upwards, ascending regularly in the easterly direction. Each post is to be referenced by a pyramidal mound six feet square at the base and thirty inches high, with four pits, four feet square and eighteen inches deep, placed square with the boundary line.

Rock posts are preferable to soil posts for permanency and ease in planting. They are to be cemented or leaded into rock or may be anchored with fused sulphur. A rock mound may be substituted for the earth mound and the pits omitted where necessary.

Where the use of soil posts is enforced by the nature of the terrain, the post shall be formed by cementing a rock post in the head of a 1½ x 48-inch iron pipe driven in place, as is customary in Manitoba.

Levelling

Continuous spirit levels are to be run along the boundary line. Each portion of the line is to be levelled and check-levelled to an agreement within 0.1 foot multiplied by the square root of the number of miles levelled. The elevation of the top of each monument is to be recorded to the nearest one-hundredth of a foot. Bench marks, which may consist of a six-inch spike in a blazed tree or a cross chiselled in solid rock, are to be located adjacent to each monument and at other suitable points, based on the rule that they should be spaced at intervals not exceeding one mile.

Ice surfaces on lakes or rivers should not be used to transfer levels from one side of a body of water to the other. In some cases, it may be necessary to effect water transfers by opening holes in the ice cover but this expedient should only be used in case of extreme necessity.

The datum for levels will be bench mark 442 placed on the Saskatchewan-Northwest Territories boundary in 1958. Elevation 1164.18 is to be assumed for this bench mark and it should be substantiated by levelling from bench mark 441 (1151.68) or Monument 190 (1150.24).

Positions on Air Photographs

The positions of all monuments and the points where the boundary line crosses rivers creeks, lakes and other identifiable topography are to be pin-pricked on vertical air photographs. The identification and chainages of these points and the monument numbers are to be noted on the backs of these photographs.

Returns of Survey

The returns of the survey are to consist of:

1. General Report
2. Plan of the survey at a scale of 40 chains to 1 inch, including a profile to the same linear scale with a suitable vertical scale. The profile should contain a statement about the datum used
3. A fair copy of the field notes
4. The original astronomical observations for azimuth and time
5. A list of monuments erected, including the number, description, azimuth and distance to the adjacent monuments in each direction, total distance in miles and chains from the starting point, and the elevation
6. Pin-pricked vertical air photographs
7. Official diary
8. Original level books
9. Original chainage and transit note books for checking purposes, along with the calculation or computation sheets used.

Fall Season, 1961

Although the survey had reached Hudson Bay in April 1960, the work had been done under extreme pressure in the later stages because of bad weather and the necessity to withdraw to Churchill before spring flooding closed the route down the coast. As a result, the surveyor did not succeed in making sufficient astronomic azimuth observations or properly connecting the levels to tidewater in the Bay.

The Commission therefore decided that the surveyor should return to the boundary to connect to sea level in Hudson Bay and to make a sufficient number of astronomical observations to fulfill the requirements of his previous instructions. Instructions for the supplementary work were issued on August 15, 1961. The following are extracts therefrom:

"*Azimuth*

You are to make precise astronomic observations to determine the azimuth of the monumented boundary at each of the following five points:

1. Monument 170 or Monument 171,
2. Any one of the Monuments 163 to 167 inclusive,
3. Monument 152,
4. Monument 106 or Monument 107,
5. Monument 86 or Monument 87.

These observations are to be made in accordance with the azimuth requirements specified in your 1958 instructions.

If in the course of this work you discover any significant error in your 1960 survey, you should make every effort within the limits of the funds allotted to you to determine the extent and location of the erroneous work and what further field work may be necessary to achieve conformity with the principle of your original instructions.

"*Levelling*

You are to level and check-level between the cap of Monument 171 or other suitable bench mark of your previous survey and the water level of Hudson Bay recording the time and date of the water level readings. This levelling is to be done in accordance with the levelling specifications contained in your 1960 instructions. The Canadian Hydrographic Service recommends that this tie to sea level be done by establishing a temporary bench mark close to the high water mark and then making several determinations of the difference in elevation between this bench mark and the still water level, recording the time (to the nearest minute) of each water reading. If possible, these readings should be made when the water is reasonably calm and the wind not too strong. In your field notes you should record the state of the water and the approximate speed and direction of the wind.

"*Returns*

Your returns shall consist of a detailed report on your work with a table summarizing the results, a diary covering the complete period of the work and all the original field notes forming the basis of your report. In addition, the results of your azimuth observations are to be incorporated in your final returns for the 1960 survey and the effect of this is to be explained in your report, providing the previous work proves to be conformable to the relevant instructions".

CHAPTER III

SURVEY OPERATIONS

Astronomic Latitude Determinations, Summer 1957

The Geodetic Survey of Canada instructed G. A. Corcoran, D.L.S., of their staff to make the astrofixes asked for by the Commission.

Early in the spring, arrangements were made with Saskatchewan Government Airways to provide transportation along the Saskatchewan portion of the boundary and with the Manitoba Government Air Service for transportation along the Manitoba portion. From information received concerning ice conditions, it was estimated that a start on the boundary assignment could not be made until about the end of June.

Leaving Ottawa at the end of May, Mr. Corcoran and his party proceeded to Prince Albert, Saskatchewan, and completed an unrelated assignment while awaiting conditions suitable to start the boundary assignment.

On July 1, Mr. Corcoran and one assistant left Prince Albert for Thicket Portage Manitoba, which was to be the advance base for the Manitoba portion of the boundaries.

Purchasing supplies at The Pas, en route, they arrived at Thicket Portage on the evening of July 4, where they found that their camp equipment had already arrived.

On the morning of July 5 they left on an Otter aircraft for Baralzon Lake some 340 miles away. At a refuelling stop at Southern Indian Lake, arrangements were made with a Manitoba Government employee to relay messages from Mr. Corcoran to the aircraft base at Thicket Portage concerning the movements of the survey party.

On reaching the vicinity of the boundary, it was discovered that all the lakes were still ice-bound and the aircraft was forced to return to Southern Indian Lake and unload the camping equipment. It then proceeded back to Thicket Portage where the party proposed to stand by until the lakes were free of ice.

A second attempt to reach the boundary was made on July 28 but unfavourable weather conditions developed and the aircraft was again forced to return to base at Thicket Portage.

On the following day, July 29, a further flight was made and this time the party arrived safely at Baralzon Lake.

The weather was fairly good and by the night of August 3 the astronomic observations were completed and station C-2 established.

Owing to prior commitments, the aircraft did not arrive until the afternoon of August 7 to move the party to the next station at the junction of the sixtieth parallel and the Manitoba-Saskatchewan boundary. After leaving Baralzon Lake, bad weather set in, and the aircraft was forced to land on Poorfish Lake west of Nueltin Lake.

The following morning, August 8, the party reached the second station, S-10-C, on Hasbala Lake, just south and west of the corner between Manitoba and Saskatchewan.

The weather at this station was fairly good and by the night of August 11 the necessary observations had been made. The astrofixes requested by the Manitoba-Northwest Territories Boundary Commission were thus successfully completed. On August 13, a Beaver aircraft from Saskatchewan Government Airways moved the party to station S-11-C on the Saskatchewan-Northwest Territories boundary to continue the astronomic work required on that boundary.

Astronomical data and descriptive material for stations C-2 and S-10-C are given in Appendix I.

Demarcation Surveys

While it has been customary in the survey of the boundary between two provinces or between a province and a territory, to entrust the field work to a surveyor who was qualified to practise on both sides of the line, this has not been invariable.

In the case of the Manitoba-Northwest Territories boundary survey, it was agreed that, as the boundary position was mathematically predetermined and not subject to on-the-ground discretion, it would be satisfactory to have a Manitoba Land Surveyor take charge of the survey. Moreover, as the Commission agreed that the direction and administration of the survey should rest with the Manitoba Commissioner, at that time H. E. Beresford, Director of the Surveys Branch in Manitoba, it was considered advisable to appoint a surveyor from his staff who had considerable experience in base-line surveys in northern Manitoba, to take charge of the survey.

Accordingly, instructions were issued to A. C. Roberts, M.L.S., to proceed with the survey. His assistant was L. E. Boutilier, M.L.S., also a member of the staff of the Surveys Branch.

Field Operations, Winter 1958–59

Organization

Preliminary arrangements for hiring personnel, purchasing supplies and equipment, etc., were made at Winnipeg under direction of the Manitoba Commissioner.

Two Wild T2 theodolites to be used for observing and line production and three sidereal watches were provided by the Surveys and Mapping Branch of the federal Department of Mines and Technical Surveys. The tapes to be used on the survey were calibrated at the National Research Council laboratory at Ottawa.

Arrangements were made with the Manitoba Government Air Service to provide air transportation to and from the boundary and along the line as the work progressed.

A 40-watt radio transmitter-receiver was provided by the Manitoba Government Air Service and a man was hired to operate another transmitter-receiver at Lynn Lake as a relay between the town of The Pas, which was the main northern station, and the various camps that would be set up along the boundary.

Moving camp with an Otter aircraft.

Hauling firewood to camp with Eliason motor toboggan.

Transport to and from work by aircraft.

The party, consisting of twenty men, was made up as follows:

Personnel	*Duty*
Chief of party	Direction and general supervision
Assistant chief	Alignment and observing
Four chainmen	Main and check chainage
Leveller and two rodmen	Main and check levels
Pilot transitman	Advance alignment for axemen
Mounder and two assistants	Monument construction
Picketman and three axemen	Line cutting
Toboggan driver	Wood supply in camp, etc.
Cook and helper	

Eleven of the group had experience on similar surveys in Alberta and Saskatchewan and were residents of these provinces. The leveller was a resident of Ottawa, Ontario, and the remaining members of the party were residents of Manitoba. A pilot and engineer for the aircraft were also attached to the party.

Transportation

Two Otter aircraft were supplied to transport the party and equipment from Lynn Lake to the starting point of the survey. One of these aircraft, with its aircrew, was to be based in camp throughout the survey. At monthly intervals it would return to the Lac du Bonnet base for maintenance service and be replaced by the other.

The aircraft were to serve three main purposes:

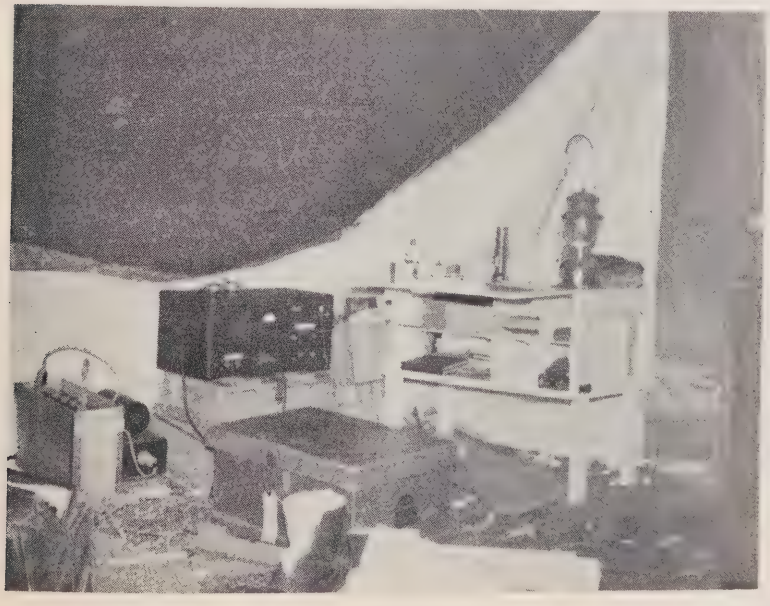
1. To carry food, gasoline and other supplies to camp from the railhead at Lynn Lake, approximately 235 miles to the south. Weather over this route was unpredictable and to ensure adequate supplies in camp in the event of adverse flying weather, a minimum of two weeks' supply was maintained at all times.
2. To move the camp ahead as the survey progressed. Twelve such moves were made and each required a full day. However, on most moving days a few members of the party would continue some aspect of the technical work to maintain uniform over-all progress. An average of six trips by the aircraft was required to move the camp and personnel.
3. To provide transport along the survey line on special occasions. This included airlifting the men to and from work when conditions were favourable and when an effective saving in time and energy could be achieved. These trips were sometimes combined with reconnaissance flights or supply trips to the railhead. They also saved many hours of tedious walking and were very effective in maintaining a high level of party morale.

Two Eliason motor toboggans were loaned by the federal Department of Mines and Technical Surveys, one for transporting wood for the camp stoves and the other for moving the mounding party and its equipment. Occasionally both toboggans were used for transporting men to and from work, especially across large lakes.

Camp No. 4 on the sheltered northwest shore of lake.

Camp Accommodation

The members of the survey party were to live in tents provided with double wall and airtight heaters. Five sleeping tents and a cook tent were provided, four men to sleep in each and the cook and his helper to sleep in the cook tent. The tent provided for the chief, assistant and engineer was also to serve as an office, and house the radio transmitter. The cook tent was also to be the dining tent. A spare tent was carried



Office tent with radio and portable desk.

Survey Operations

On December 29, 1958, Mr. Roberts and five men, with instruments and equipment, flew to Lynn Lake in two Otter aircraft, while Mr. Boutilier left by rail for The Pas to meet the eleven members of the party from Alberta and Saskatchewan. They assembled at Lynn Lake on December 30.

Owing to adverse flying conditions, the party was held up at Lynn Lake until January 3 when Mr. Boutilier and three men were airlifted to the boundary at the northwest corner of the province. On January 5, 6 and 8 the rest of the party with the balance of equipment and supplies were taken to Camp No. 1. On January 8 Mr. Boutilier started the retracement between Monuments 191 and 190 of the Saskatchewan-Northwest Territories boundary survey and started cutting line easterly from Monument 191.

The whole party was at work on January 9 but heavy snow and strong winds hampered all aspects of the work.

Clear, cold weather set in on January 13 ($-55°$ on January 16) and on the 17th, one of the rodmen reported a frozen toe with slight freezing on the adjoining one. After unsuccessful first-aid, it was decided to send the man to Lynn Lake hospital for medical care. It was learned later that the frozen toe had to be amputated. This unfortunate occurrence was the only accident of any consequence during the survey.

By the end of January twenty-two miles of the line had been cut. The following is a rough breakdown of the 31 days of January:

7 days moving party and equipment into Camp No. 1, including lost time through bad weather

1 day completing move-in with part of party starting survey

17 days on line, including one rather unproductive day in a blizzard

4 days in camp, Sunday and owing to blizzards

2 days for two camp moves, some men working on line both days.

The weather continued cold and windy during February, with snow at the beginning of the month and light intermittent snow during the last few days of the month. No time was lost and by February 28 the line was cut to Mile 59.

Up to Mile 40 the cutting had been consistently heavy, but as the line progressed the trees became smaller. A breakdown of the work during February was as follows:

19 days on line

4 days in camp, Sundays

5 days for camp moves.

Good progress was made in March despite snow or blowing snow on thirteen days during the month. Temperatures moderated a little, ranging from a low of $-37°$ on March 16 to a high of $+35°$ on March 27.

On March 6 the line was cut to the west shore of Nueltin Lake, the first large body of water to be crossed. Hearne Bay, the southeastern arm of this lake, was reached on March 21 and here the party met a local resident for the first time, Ragnar Jonsson, a trapper. He had occupied a camp on the bay for many years and his latest visit to civilization had been some eighteen months before. He was able to provide much

valuable information about conditions in the barren land that the survey line was rapidly approaching.

As operations were planned to terminate on March 31, it became apparent that the objective of reaching Baralzon Lake could not be attained. Every effort was made to reach the barren land and this was accomplished on March 26 at Mile 103 (Monument 74) where tree growth all but disappeared.

To assist in planning for the next season's operations in the barren land and to gain experience in surveying across this treeless territory, the line was continued for another six miles where the final monument for the season, No. 78, was placed on March 30, 109 miles from the starting point.

On March 29 five members of the party were taken to Lynn Lake and thence home by rail; the rest of the party left the following day.

The time breakdown for March was as follows:

19 days on line, one day limited because of strong wind
5 days for camp moves
6 days in camp, Sundays or due to blizzards
1 day moving party by air to Lynn Lake.

Summary of Results

Line Production

The line was surveyed by projecting chords of 486 chains, perpendicular to the astronomical meridian through the mid-point of each chord. The deflection of successive chords was 9 minutes and 6 seconds of arc, except where it was varied to adjust the alignment to conform with the astronomical observations. At seven chord-terminal points, the ground was unsuitable for the erection of a monument, and a short chord was established from the most easterly monument on the chord to the west, to the first or most westerly monument on the chord to the east.

A forward station—using red and orange plastic targets for line production.

The two-target method was used for line production and had the advantage of being applicable to both straight-line productions and deflections. This method requires two targets straddling the line at the forward station. The instrument is pointed on the back sight, the telescope transited and the horizontal circle read. A pointing is then made on each forward target with horizontal circle readings being taken on each pointing. The instrument is then turned 180° and the operation repeated. An equal number of pointings are taken with circle right and left until satisfactory agreement is obtained. Mean values are then obtained for all pointings and the true line established by proportioning the distance between the forward pickets in accord with the respective angular measure to each picket.

This method was found superior to the method of double-centring formerly used on base lines and other control surveys, and its practical application has been facilitated by modern survey instruments.

Azimuths

Observations for azimuth were made on each 486-chain chord throughout the survey. Altogether, twenty-six sets of observations were made, of which almost one half did not meet the prescribed standards. The average value for the probable error of the means of the twenty-six sets made was 1.7 seconds. In an attempt to get better values, more than the required minimum of three individual observations per set were recorded in eighteen out of the twenty-six cases. The final accepted value of a set was always the mean of all observations made in the set.

Very strong winds, low temperatures and haze made observing difficult. When the specified tolerance was not met, the Manitoba Commissioner was kept informed of the circumstances.

All observations were made with the Wild T2 theodolite. The method of observing for azimuth was as follows:

Chaining to Monument 5.

The theodolite was set up and accurately centred over the station. The instrument was levelled, using the stride level, and then sighted on the reference object for the observation. The telescope was then aligned with Polaris, using the known approximate azimuth and altitude of the star. An accurate pointing was made on Polaris and the exact time recorded. The stride level, with the large reading to the west, was read and recorded, reversed, allowed to settle, and then read again. The horizonal circle reading on the star was then determined without moving the telescope, by making and recording three successive independent micrometer settings. The telescope was then pointed on the reference object three successive times and the horizontal circle reading was recorded for each pointing. The telescope was then transited and the above procedure repeated.

This constituted one complete observation and a complete set consisted of from three to six observations.

The sidereal watches were checked by radio time signals from Ottawa and Washington for all azimuth observations, and on eleven occasions meridional transits of stars were observed as a further check.

Linear Measurements

All length measurements were made with steel tapes calibrated by the National Research Council at Ottawa. Two independent measurements were made, the first in links using a 500-link, $\frac{1}{8}$-in. tape and the second in feet with a 200-ft. $\frac{1}{4}$-in. tape. Separate chaining crews carried out each chainage to maintain complete independence of the two measurements. The final accepted length of each line was the mean of the results of two independent measurements.

Two methods of chaining were considered by the Commissioners, one providing for the tape to be held clear of the ground by using supports at each end and in the middle, and the other by using plumb-bobs. In view of the comparatively gentle undulations anticipated along this boundary, provision was made in the instructions for the simpler method of chaining, provided the required agreement between the main and check chainage was maintained. Mr. Roberts encountered no difficulty in meeting the prescribed tolerance by using the simpler method and it was followed throughout the survey.

Both sets of chainmen used the same methods of operation and exercised great care. Corrections were applied for temperature, slope, sag and tape length. To ensure greater accuracy, all slopes were measured with a transit. Tape tension was controlled by the use of tension handles (spring balances) regularly tested with a standard 20-lb weight calibrated by the National Research Council. The tapes had been calibrated under a tension of 20 lb.

Monumentation

All monuments erected comprised special boundary rock posts marked "NORTH-WEST TERRITORIES—MANITOBA" with the date, serial number and statement of the penalty for removal. These posts were anchored with fused sulphur either in

rock or in the tops of iron pipes $1\frac{1}{2}$ in. in diameter and 48 in. long driven into the ground. All posts were referenced by a pyramidal mound built entirely of rock, the size of the mound, except in one case, being from 4 ft to 6 ft square at the base and at least 30 in. high, depending on the supply of rock available. The one exception was Monument 49 located on top of a very steep and prominent esker, where, owing to scarcity of suitable rock, the mound was only 3 ft square at the base and 2 ft in height.

The difficult task of mounding in the winter was partly relieved by the use of a Pionjar gasoline-powered rock drill, dynamite and the motor toboggan. Large surface boulders were drilled and blasted and the shattered rock hauled to the monument site by the motor toboggan. Mr. Roberts reported that the jagged rock, having good locking qualities, was most suitable for the erection of stable mounds.

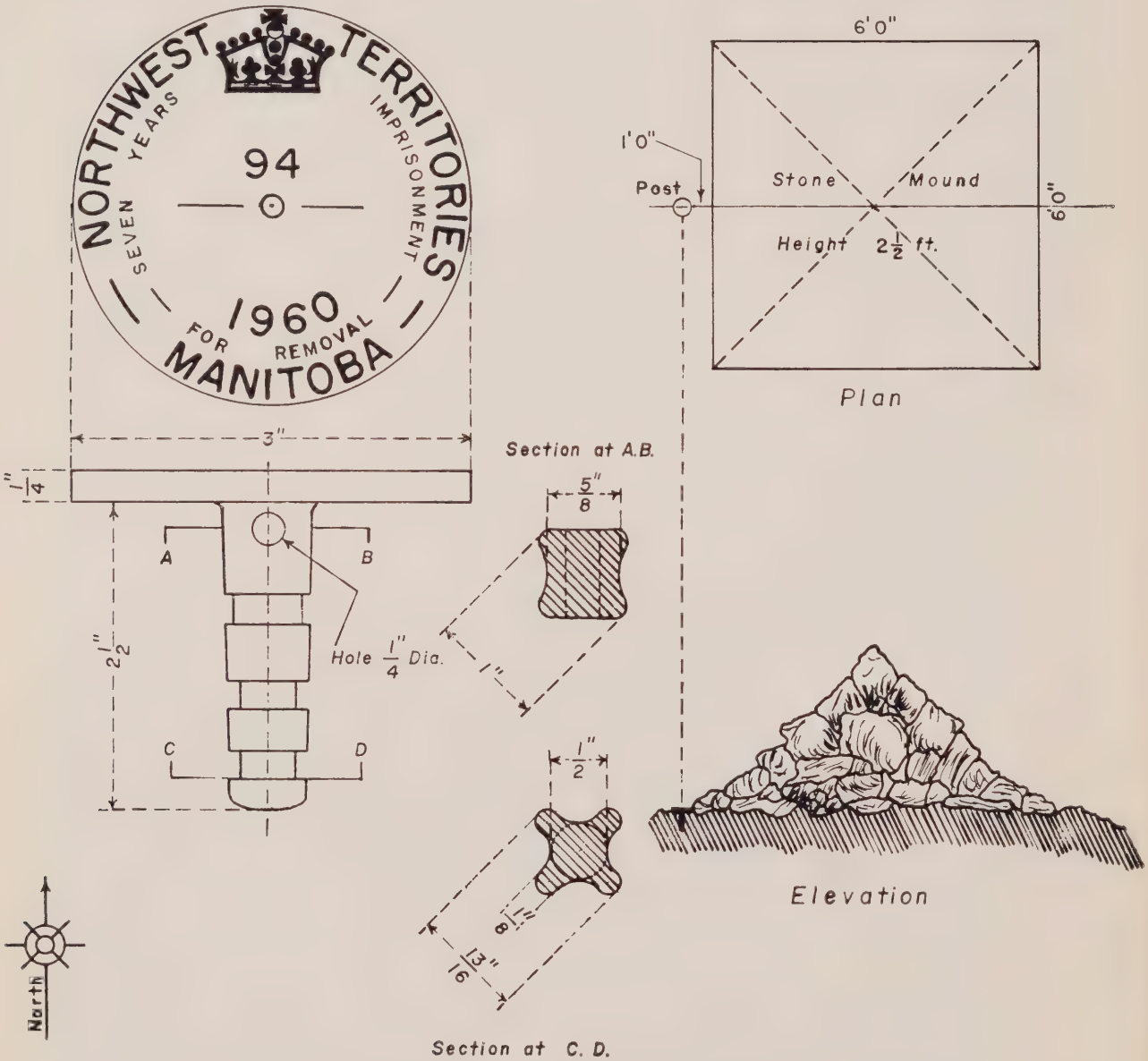
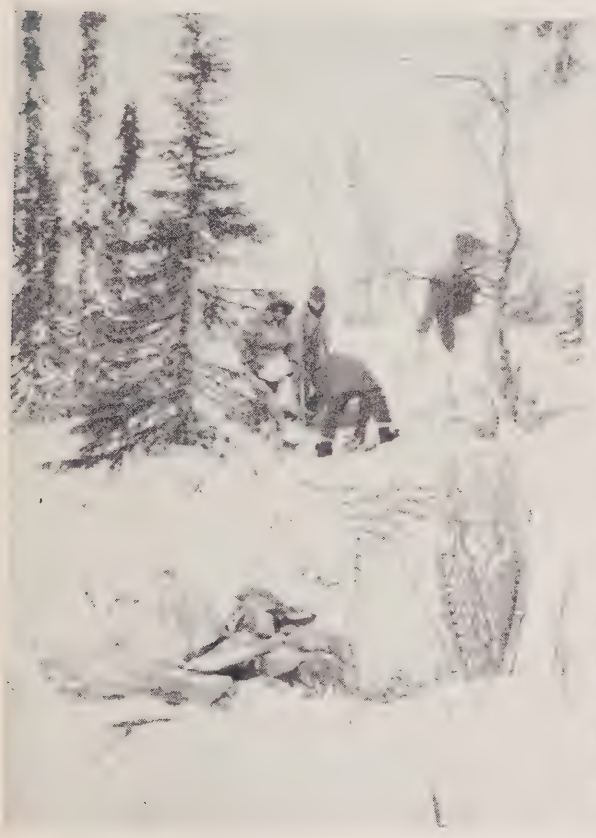


Diagram showing rock post and stone mound.

Levelling

Spirit levels were run easterly along the line and check levels were also run in the same direction. Stadia readings were recorded on all main level sights with stadia ties to bench marks, survey monuments, chainage tally points and intermediate points for profile.

Bench marks, consisting of either a 6-in. spike driven into a blazed tree or simply a notch cut in the tree, were made at approximately one-mile intervals along the line and also close to the shores of all lakes of significant size. One bench mark in the



Constructing a mound from blasted rock.

Typical bench mark.

Looking south along esker near Monument 49.

barren land, where no trees were available, consisted of a cross chiselled into the top of a boulder. One hundred and twelve bench marks were established during the season. They were numbered consecutively and inscribed accordingly.

The datum for all elevations determined was bench mark 442, elevation 1,164.18, on the Saskatchewan-Northwest Territories boundary, adjacent to Monument 191 on that boundary.

Examination of the level returns disclosed that levelling operations were not up to standard, and that a complete check had not been obtained. A notation, therefore, has been made on the atlas sheets that elevations shown are not checked.

The low standard of levelling was due mainly to the inexperience of the leveller on this class of work carried out under extreme winter conditions. As levelling operations were supplementary to the boundary survey and had no influence on the definition of the boundary, the Commission did not consider that further levelling was justified. The elevations and profile shown on the atlas sheets provide considerable additional information about the territory covered by the boundary and are a good reference for any investigation to be carried out in the area, but they should be used with some caution.

Line Clearing

Through all wooded areas the boundary line was cut out to provide a minimum sky-line width of 6 ft and suitable trees on each side of the line were blazed in accordance with instructions.

Typical bare, boulder-covered hill. Tellurometer station A24 in background.

Connections to Previous Surveys

By means of triangulation, two tellurometer traverse survey stations, A22 and A24 established in 1958 by the Topographical Survey of the Department of Mines and Technical Surveys, were tied in. Station A22 is situated on a small wooded hill about 4,000 ft north of the line about 34 miles east of the starting point, while A24 is on a flat, bare hilltop about 4,700 ft south of the line near Charlie Lake.

Conclusion of 1958–59 Survey

The field operations proceeded quite smoothly. As often happens on surveys of this nature, the last three weeks produced almost as much completed line as the first eight weeks, due in part, to longer days, lighter cutting, more experience and eagerness to complete the work and return to civilization.

A large amount of work was accomplished and much of the credit for this must go to the fine crew, the splendid cooperation of the radio operator at Lynn Lake, the Manitoba Government Air Service, the Department of Transport weather station at Brochet, and to the cook who prepared excellent food throughout the survey.

SURVEY STATISTICS
1958-1959

Boundary completed	109 miles
Monuments placed	78
Rock post, stone mound	68
Post in iron pipe, stone mound	10
Monument interval, average	1.40 miles
Monument interval, maximum	5.74
Monument interval, minimum	0.06
Bench marks established	112
Average distance between bench marks	0.98 mile
Average progress of the completed boundary	2 miles daily
Camp moves	12
Days lost due to weather, transport	5
Accidents	1 major
	4 minor
Sickness in camp	4 minor cases
Labour relations	Good
Party strength	20

Field Operations, Winter 1959–60

The objective for the 1959–60 winter season was to complete the boundary to Hudson Bay.

This was a big task involving the survey and monumentation of 140 miles of boundary across the barren land.

The six miles surveyed in the barrens during the previous season had given some idea of the difficulties to be encountered.

It was evident that in this treeless terrain subjected to very strong northerly winds, low temperatures and sudden blizzards, the kind of air transport and camp used during the first season would not be practical. The main factors affecting the choice of methods of transport for the second season were:

1. Progress of survey would be rapid across open country, necessitating frequent moves.

2. Unusual safety precautions would have to be taken for men in open country in the event of sudden and blinding blizzards occurring with little warning.
3. Any air support would require prepared runways due to the drifted condition of snow in this wind-swept country.

Under the extreme climatic conditions expected, consideration was given to heavy ground transport consisting of cabooses drawn by caterpillar tractors. This would permit the camp to be moved ahead each day with a minimum of assistance from the survey crew. Camp would, at all times, be within the day's work and walking would be reduced to a minimum. The tractor trail would also provide an artificial marker across the immediate area of operation and assist in guiding men to camp in the early stages of any storm. It was essential while working in this area that every precaution possible be taken to provide for the safety of the men.

A. C. Roberts, M.L.S., was re-appointed to take charge of the survey for the second season with T. H. Stevens, M.L.S., of the Manitoba Surveys Branch as assistant.

In September 1959, Mr. Roberts made an aerial reconnaissance of the unsurveyed part of the boundary to see whether any physical features would obstruct the passage of tractor trains. He found that, with the exception of one boulder-strewn area some 10 miles in extent 20 miles west of Hudson Bay, the use of tractors was quite feasible. An examination of airphotos showed several possible routes through the boulder area, so a decision was made to use tractors for transportation to, along, and from the boundary.

Organization

The members of the Commission and Mr. Roberts made many enquiries about conditions in the barrens and possible tractor routes from Churchill to the starting point of the season's work.

At the request of the federal Commissioner the Deputy Minister of National Defence agreed to the loan of Arctic clothing, freight sleighs, cabooses and sundry equipment and supplies from the Canadian Army at Churchill.

Preliminary arrangements were made to take the tractor train from Churchill northwesterly across country to the starting point for the survey, but illness of the only guide familiar with this route forced abandonment of this plan.

The alternative was to proceed northerly along the coast of Hudson Bay to the 60th parallel and thence westerly along the parallel to the starting point.

Winter freight hauls by tractor normally start at the beginning of January in northern Manitoba. However, it was considered that February and March would be more favourable months for the survey and January 20 was the date set for the tractor trains to leave Churchill. It was expected that the equipment and men could reach their starting point in 10 to 15 days, which would allow reasonable time for the survey.

The survey party comprised 18 men, most of whom had previous experience on northern surveys. The composition of the party was similar to that of the previous season except that no axemen were required and two tractor drivers were substituted

for the toboggan driver. An additional leveller was needed for check levelling, as progress along the line would be too fast to permit one leveller to do both the main and check levels. A rodman and mounder also acted as spare tractor drivers.

Departure for Survey

The assistant and six men arrived in Churchill by rail on January 7 and Mr Roberts arrived by air on January 9.

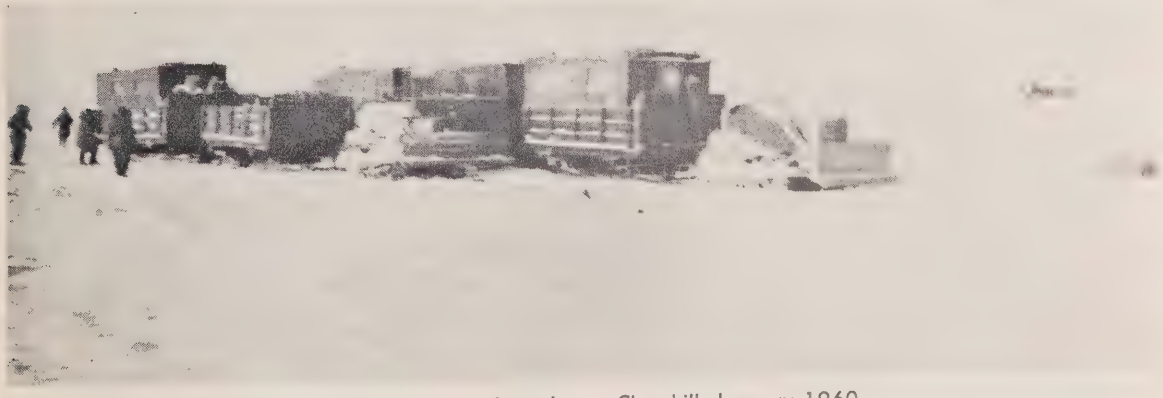
After a period of intensive preparation, which included a one-day Arctic survival course at the Army Training Wing for all members of the survey party, the advance party of eight men left Churchill by tractor train on January 25, crossed the Churchill River about seven miles southerly and then went north along the coast.

Ground transport for the survey was provided by two Caterpillar Model D6 diesel tractors, three freight sleighs, one freight caboose, three sleeping cabooses and one cook caboose. A third tractor was used from Churchill to the 60th parallel at which point it returned to Churchill. Two Bombardiers, track-driven personnel carriers, accompanied the train and were used for scouting the route ahead of the tractor train.

Despite several delays on account of mechanical breakdowns and weather conditions, the tractor train arrived at the 60th parallel on February 7 after travelling 170 miles from Churchill. Turning west, the train followed the approximate position of the parallel till it reached the boulder-pile area some 20 miles west of Hudson Bay. At this point, on February 10, Mr. Roberts flew in from Churchill to join the party. With considerable difficulty, but greatly aided by the use of a large-scale map showing possible routes and by airphotos, the boulder area was successfully passed by a route seven miles to the south.

On February 19 the rest of the party were airlifted from Churchill to a lake 30 miles east of Baralzon Lake where they joined the tractor train. Three days later, the tractor train arrived at a point four miles east of the starting point of the survey.

The delay of two or three weeks in reaching the starting point for the survey was a matter of considerable concern. It was due mainly to two factors, the difference in the characteristics of dry Arctic snow and the very limited data or experience available on heavy ground freighting in the Arctic. The tractor loads, though smaller than those normally moved on more southern freight hauls, were undoubtedly too heavy for Arctic operations of this type. The trail could not be fully plowed out in the usual



Tractor train ready to leave Churchill, January 1960.

manner owing to the occurrence of boulders in some areas and the great depth of snow in others. The resulting increased drag on the sleighs slowed progress and caused frequent breakages of towing gear.

Transportation

Transportation during the survey was provided by two Bombardiers, the two tractors, and on a few occasions, aircraft.

Their respective uses are summarized as follows:

(a) *Bombardiers*

The Bombardiers were used for a variety of purposes including trail location ahead of the tractor train, transporting men to and from work on the few occasions when camps were some distance from the line, transporting mounders and main transitman and equipment from station to station and providing shelter and warmth at lunch time. They were used to great advantage in connection with astronomic observations at night.

(b) *Tractors*

The main purpose of the tractors was to haul the freight sleighs and cabooses to and from the boundary and along the line during the survey. Each tractor was equipped with a bulldozer blade and a winch with 75 ft of steel cable.

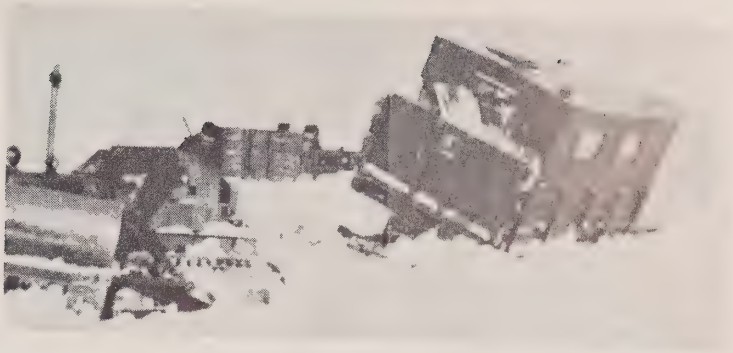
On the survey, they were used to clear snow, to find rock for mounds, to move rock fragments to mound sites and on two occasions, to prepare runways for a DC3 aircraft.

D6 Caterpillar tractor with slipped track on move from Churchill to start of survey, second season.

(c) *Aircraft*

An Otter aircraft from the Manitoba Government Air Service stood by at Churchill while the tractor train was en route to the starting point of the survey. It also transported some members of the party from Churchill to the survey camp on the boundary. A DC3 aircraft of TransAir Limited, Churchill, brought in fuel on two occasions and about the end of March, additional survey personnel, with camping equipment. An aircraft of the RCAF Search and Rescue Squadron at Churchill landed on April 1 with mail and on April 8 the same aircraft dropped a message to the tractor train indicating favourable ice conditions all the way south to Churchill.

Apart from several minor breakdowns of the Bombardiers, tractors and sleighs, all equipment proved most serviceable and was very satisfactory for this survey.



Difficulties in deep snow.

Replenishing fuel supplies by DC3 aircraft on runway prepared by tractors, on lake in barren lands.

Camp Accommodation

The mode of living was quite different from that on all previous surveys in northern Manitoba. Survey personnel had always lived in tents on remote surveys but now the absence of trees and the severe weather conditions prevailing in the area required a more stable and sheltered type of accommodation.

Three sleeping cabooses, or wanigans, were loaned by the Canadian Army at Churchill and a cook caboose with space to seat 10 men at a meal was loaned by the Manitoba Department of Agriculture.

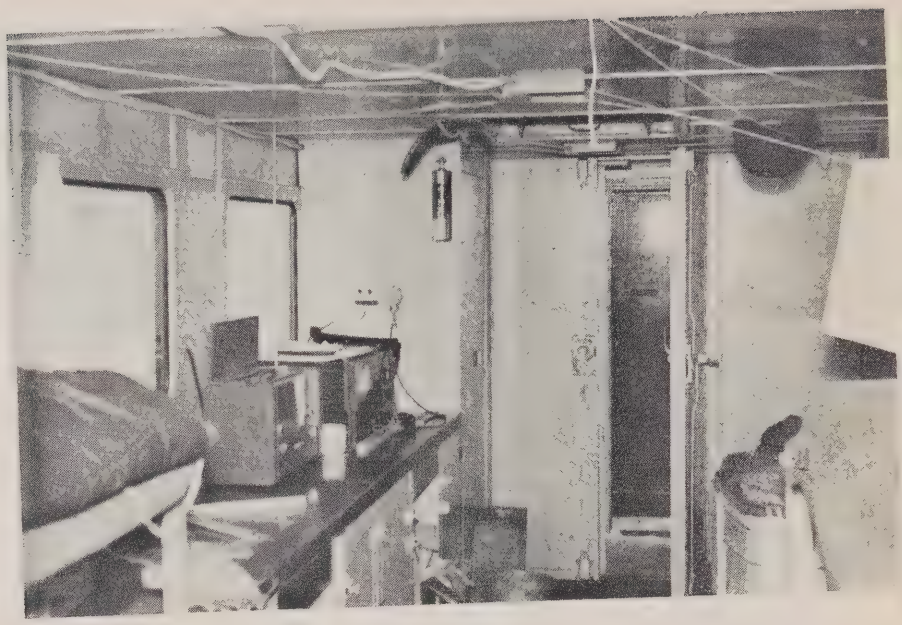
One of the sleeping cabooses served as an office and was equipped to accommodate four men. It also housed a 100-watt radio transmitter-receiver. The other two sleeping cabooses were equipped to accommodate 13 men altogether.

The camp was moved every working day and there is no doubt that the amount of work completed during the season was due in large measure to the convenience and comfort of this type of accommodation and the ease with which it was moved along the line.

In his report, Mr. Roberts describes a typical camp move thus:

"The process of camp moves was very simple and consisted of hitching the sleigh and caboose units to the tractors and pulling them to the new camp position.

"Throughout the survey I endeavoured to locate the camp near the position of the end of the day's work. The great advantage of having the route in from the coast along the parallel was that we didn't need to locate a new road going east again. This would have required a person familiar with airphotos to reconnoitre ahead each day in one Bombardier. Also the road was frozen hard and made easier passage for the train.



Inside office caboose, showing 100-watt transmitter-receiver and portable short-wave radio.

Camp during a blizzard.

After a blizzard; snowdrift in the lee of a caboose.

"The few days when there was some uncertainty about the weather I would delay the camp move till noon in case a blizzard should come up.

"The morning of a camp move, which was every working day, one tractor driver would hitch up the store and cook cabooses and move them to the new campsite ahead. When they arrived at the site, which was usually a lake, the tractor would blade the snow away from the ice to provide three level parking spaces for the three train units. This tractor would then return for the third unit. The other tractor might spend the morning hauling rock for mounds or just hitch up and haul his unit into the new camp and set up the aerial for the two-way radio".

Survey Operations

No time was lost in starting work on the boundary. On February 22, the same day that the party arrived at the starting point, a part of the boundary, surveyed the previous season, was retraced and relevelled and the survey of the next part was commenced.

Good progress was made during the rest of February and 18 miles of line were surveyed, despite the loss of two days on account of blizzards. The first two days in March were also lost on account of blizzards, but subsequent clear, cold weather permitted the work to be carried on vigorously. The most severe blizzard of the season on the line occurred on March 20 and 21 with visibility restricted to 20 ft and wind gusting to 50 miles per hour.

As April 1 had been set as the probable latest possible date for the tractors to return down the coast, it was realized that a tremendous effort was needed to complete the line to the coast and a program of longer hours of work was instituted. In addition, arrangements were made to fly in Mr. Boutilier and two men with tenting equipment, to help finish the survey in case the tractors and cabooses had to leave. They arrived on March 28.

Work had continued at an accelerated pace and 97 miles were completed in March, despite the fact that five week-days and three Sundays were spent in camp due to severe blizzards.

The deadline for the tractors to return south having been extended to April 5, extra efforts were made to reach the coast and this was finally achieved on April 6 when Mr. Ney's monument (*see* Appendix I) was tied in. During the four days worked in April, 25 miles were surveyed. The maximum progress on any one day was on April 3 when eight and a half miles of line were surveyed.

The tractor train started south on the morning of April 6, while the members of the party who had remained to complete the line to the shore followed later in one of the Bombardiers, rejoining the tractor train in the evening. After encountering the most severe blizzard of the season near the mouth of the Seal River, which caused a delay of several hours, the party finally reached Churchill on April 10.

Equipment on loan from the Army was returned, necessary freight shipments were arranged and Mr. Roberts and his two assistants returned to Winnipeg by air on April 11. The rest of the party left for their homes by rail on April 12.

Summary of Results

Line Production

The method of line production on this survey was the same as that used in the previous season. In using the two-target method, described earlier, it was found that by using bright orange cloth on the pickets instead of the red cloth used previously, the signals were more easily identified. Owing to the absence of trees, wood laths were used, both for line pickets and station signals, throughout the survey.

Azimuths

Thirty-one astronomic observations for azimuth were made. Before and after each observation, time checks were obtained by radio from Station WWV, Washington, D.C., while in seventeen instances, local sidereal time was also determined by direct stellar observation.

Strong northerly winds and the absence of trees made observing difficult. A collapsible shade was made to shield the transit and provided some protection. The snow and ice-crystal haze found in the barren land reduced visibility upward so that Polaris could seldom be seen before 4 p.m. More than half of the observations were made at night. Under these circumstances it was extremely difficult to obtain acceptable observations. To keep pace with the rapid progress, the surveyor was usually forced to observe under poor conditions. As a result of this only eleven of the thirty-one sets of observations taken met the accuracy requirements specified in the instructions, and of the remaining twenty sets, six had to be completely rejected. The azimuth control along some parts of the boundary was therefore considered incomplete and it was to rectify this that the Commission ordered further work on the boundary in 1961.

Sunshade used while observing.

Free plumb-bob method of chaining.

Linear Measurements

The method of chaining was the same as that used during the previous season. The country was generally flat and the chainmen had no difficulty maintaining the required degree of accuracy as well as maintaining an exceptionally good daily rate of progress.

Monumentation

Ninety-three monuments, similar to those made in the previous season, were erected on this part of the boundary, at an average interval of one and a half miles. No adjacent monuments are more than three miles apart and except for some chord terminal monuments, all are intervisible. All mounds were made of rock fragments and are approximately 5 ft square at the base and at least 30 in. in height. The posts were numbered consecutively from No. 79 near the start of the season's survey to No. 171 on the west coast of Hudson Bay.

There were no trees on the line suitable for use as bearing trees but a few trees of sufficient size were found close to the line and were blazed.

A summary of the monument data is given in Appendix II.

Levelling

Commencing at Monument 78, established during the 1958-59 season, continuous spirit levels were run along the boundary. Progress on the line was too rapid to permit both initial and check levels to be run by one leveller, so two levellers were assigned to this work. Both worked eastward except on a few occasions when westward runs were required for re-checking purposes.

Bench marks established consisted in seventy two cases of the rock posts placed to mark the boundary. In sixty other cases 1-in. holes drilled in nearby referenced rocks served the purpose, and in one case a cross chiselled on rock was used. The use of the rock posts and the 1-in. holes as bench marks was approved by the Commission before the survey commenced.

Lack of time at the end of the field season prevented making the required tie to sea level at Hudson Bay. The jumble of broken sea ice along the shore made the task a great deal more difficult than had been expected.

Connections to Previous Surveys

Three ties were made to previous survey monuments, viz., a Topographical Survey traverse station, A41, west of Baralzon Lake, Mr. Corcoran's astrofix, C-2, on Baralzon Lake and Mr. Ney's astrofix at Hudson Bay.

Conclusion of 1959-60 Survey

In concluding his report for this season, Mr. Roberts states:

"I feel that the season was very successful, and gave a better result than would have been estimated at the time the tractor train was travelling up the coast of the Hudson Bay.

"I feel sure that had there not been the urgency to complete the survey this season, the accuracy attained would have been increased. . . .

"The morale of the party was high at all times and this, together with the willingness of all members of the party to give their utmost in time and energies to their duties, contributed to the good mileage produced.

"The cook was excellent, working under difficult conditions while travelling in and out and working long hours during the survey, but always producing very appetizing meals and always with a cheerful word. This was the main factor in the maintenance of high morale in the party.

"In concluding this report I wish to express my appreciation for the wholehearted cooperation I received from everyone contributing to the survey, for without such cooperation, a survey of this nature in such a remote area would be impossible.

"In particular, I wish to sincerely thank the following men:

"All the personnel of the field party who worked extended hours in order to cooperate and complete the survey and suffered discomforts by working in adverse weather conditions. In particular, the technical men who spent many hours on note reductions in the evening, and the maintenance men who repaired parts at night in order to keep the equipment serviceable at all times.

"All the members of the Canadian Army, both in Winnipeg and Fort Churchill, who cooperated wholeheartedly in our project, especially in assisting in the early maintenance of our equipment.

"The employees of the Department of Transport radio station at Fort Churchill who maintained our only link with the south.

"The manager and staff of TransAir Limited, Churchill."

SURVEY STATISTICS
1959-60

Boundary completed	140 miles
Monuments placed	93
Rock post, stone mound	77
Post in iron pipe, stone mound	16
Monument interval, average	1.5 miles
Monument interval, maximum	2.92 "
Monument interval, minimum	0.42 "
Bench marks established (including 72 rock posts)	132
Average distance between bench marks	1.06 miles
Average progress of the completed boundary	4.4 miles daily
Days lost due to weather, transport	11
Accidents	1 minor
Sickness in camp	Nil
Labour relations	Good
Party strength	18-21

Field Operations, September, 1961

In accordance with instruction issued by the Commission dated August 15, 1961 Mr. Roberts made plans to return to the boundary to make certain additional observations necessary to achieve conformity with the principles of his original instructions.

Organization

Preliminary arrangements were made in August, 1961, with Arctic Airways of Churchill to take the party to the boundary, move it along the boundary and return it to Churchill.

A Wild T2 theodolite, a level, rod, chain, sidereal watch, short-wave radio and camping equipment were obtained from the Surveys Branch of the Department of Mines and Natural Resources at Winnipeg.

The Manitoba Government Air Service supplied a 12-watt radio transmitter-receiver operating at frequencies of 4,895 and 5,680 kc. the latter being the frequency used by the Department of Transport at Churchill, whose officials had agreed to transmit and receive any messages involved in the project.

The party consisted of Mr. Roberts and one assistant, a survey student from the Surveys Branch at Winnipeg. They lived in tents and cooked their own meals.

Survey operations

The party left Churchill in a Norseman aircraft of Arctic Airways on September 1, intending to establish its first camp on the boundary some two or three miles from the shore of Hudson Bay. The lakes in the vicinity, however, were too shallow and boulder-strewn to permit landing and the nearest suitable lake was found about seven miles inland between Monuments 166 and 167. The first camp was established there.

On the morning of September 2 the sky was overcast and unsuitable for observing so Mr. Roberts and his assistant walked to the coast where they completed the level tie to the waters of Hudson Bay. As they walked along the line they plumbed a large red target on a picket over each rock post for future use in observing. On arriving at the terminal monument, No. 171, a magnesium beacon was found to have been erected over the monument by a prior survey party.

Mr. Roberts reports thus: "The flat shoreline was very deceptive because, as the tide receded, it left shallow pools which appeared to be sea level for that stage of tide, but which, upon investigation, proved to be landlocked. I obtained an accurate reading on sea level in shallow water that was clearly open to the sea and confirmed this reading by placing a target on the rod and compared this reading with the instrument reading."

After continuous cloudy weather there was a break at dusk on September 4. Three observations for azimuth were made at Monument 167 but before a fourth could be made, the sky again became overcast. September 5 dawned bright and clear and four further observations were made at Monument 167 and six at Monument 168. Referring to these observations in his report Mr. Roberts states: "In all these day-time observations I had some difficulty with the stride level because of the sun.

Typical view of boulder-strewn barren lands.

A shade was used with difficulty in the wind. I used Monument 171 (magnesium signal) for the reference object on all these pointings. When sighting on Monument 171, I was able to clearly see the targets over Monument 169, 170 and 171 and they all sighted in the same straight line with Monument 168. This was a moment of some satisfaction to me, as the production of the line at this stage of the original survey was made under the worst possible weather conditions. At no stage had we been able to view more than the nearest target each side of the instrument station, and then with difficulty through hazy blizzard conditions."

On September 6 the party moved by air to a new camp on the south shore of a large lake west of Monument 152. At this monument a number of azimuth observations were made as well as two time-star observations. In addition, the elevation of Monument 152 was determined by levelling from the bench mark to the east of it. This determination had been omitted in the original survey.

On September 12 the aircraft returned and the party moved to Monument 107. On succeeding days a number of azimuth and time-star observations were made at this monument.

The aircraft arrived early in the morning of September 17 and carried the men to Monument 86 where it waited while five azimuth observations were made with some difficulty owing to high winds. Following this the party returned to the camp at Monument 107, loaded the aircraft and then returned to Churchill, arriving at 3:45 p.m. On the following day accounts were settled and the equipment packed for shipping by rail. Mr. Roberts and his assistant returned to Winnipeg by air on September 19.

Levelling

At Monument 171 spirit levels were run from the monument down to the sea where two readings were made at the water level and a single reading on a positive high-water mark for that day. The work was verified by levelling back to Monument 171. During this process, a tie was made to Mr. Ney's 1929 monument.

Azimuths

Observations for azimuth were made in the manner described earlier. The instrument was shaded by a double thickness of white cotton sheeting held up by a bamboo tripod frame weighted down by boulders. The region is virtually treeless and in every case, great difficulty was experienced because the continuously strong winds upset the tripod shade on several occasions.

Results of the azimuth observations made on this survey have been incorporated in the final returns for the 1960 survey and are included in the summary of monument data given in Appendix II.

Completion of the Boundary, 1962

One important point of the survey still remained to be marked. This was the monument to mark the northeast corner of Saskatchewan, the northwest corner of Manitoba and at the same time the initial point of the Manitoba-Northwest Territories boundary.

The last monument on the Saskatchewan-Northwest Territories boundary, No. 191, had been placed about 10 chains west and the first monument of the Manitoba-Northwest Territories boundary, No. 1, had been placed about 30 chains east of the estimated position of the common corner. It was agreed by all three boundary commissions involved that the common corner should lie on the straight line joining these two monuments and that it should be monumented by the Manitoba-Saskatchewan Boundary Commission in the survey of that boundary.

In April 1962, acting under instructions of the Manitoba-Saskatchewan Boundary Commission, L. E. Boutilier, M.L.S., completed the survey of the northern part of the boundary between the two provinces. In accordance with the wishes of the three respective boundary commissions, he located the common corner and marked it with a special aluminum monument. A description of this monument is given in Appendix IV.

The dimensions quoted in this report for the initial course of the boundary are those determined by Mr. Boutilier.

CHAPTER IV

VERIFICATION OF FIELD WORK

Examination of Survey Records

The survey records are listed in the summary of instructions for the survey, given in Chapter II under the heading "Returns of Survey". They comprise a complete record of all phases of the work performed in the field and the office.

To ensure that Mr. Roberts had carried out his instructions and that clerical and other errors were eliminated, an examiner was selected by the Commission to examine the returns at the end of each of the two winter field seasons.

John Carroll, D.L.S., who had made several examinations of a similar nature in the past, was engaged to undertake the work.

Mr. Carroll submitted two reports to the Commission dated January 25, 1960, and February 14, 1961, covering the examination of the returns for the 1958–59 survey and those for the 1959–60 survey respectively. These reports give, in considerable detail, his findings as to whether or not Mr. Roberts had complied with the relevant instructions issued to him by the Commission.

In both reports Mr. Carroll states "In general, I find that Mr. Roberts has complied with the instructions issued to him by the Boundary Commission."

In his second report Mr. Carroll states "The Manitoba boundary is now completed By Commission decision the boundary was begun at the Saskatchewan border on the 60th degree astronomic parallel and continued along that parallel . . . . It was not influenced by ancillary control but was tied into two Geodetic Survey of Canada astrofixes and it is interesting to note that at Monument 100 (near astrofix, Corcoran, 1957) and Monument 171 (near astrofix, Ney, 1929), the positions of these monuments as deduced from the astrofixes, are approximately 60°00′00″ and 59°59′58″ respectively."

In the light of Mr. Carroll's reports, Mr. Roberts reviewed his returns, investigated any indicated discrepancies or errors and put them in final form.

Field Inspection

Owing to pressure of work and other circumstances, the members of the Commission were unable to inspect the survey personally.

Arrangements were made, however, for W. V. Blackie, D.L.S., of the Department of Mines and Technical Surveys, Ottawa, to make a technical inspection of the boundary at four points in the vicinity of Monuments 1, 78, 90 and 149.

Mr. Blackie left Ottawa on August 8, 1960, for Churchill where, with the two men assigned to his party, he completed arrangements for the inspection.

The party left Churchill for the boundary in a TransAir Limited Canso aircraft on August 11 and, after successfully completing the inspection at all four points, returned to Churchill on August 25.

A brief summary of the inspections at the various points follows.

Inspection in Vicinity of Monument 78

At Monument 76 a rock post was found, 1 ft west of a well-constructed mound, 6 ft square and about 4 ft high. Seven hundred feet east of this post the line passes

through a timbered depression where the cut line was about 10 ft wide and the stumps as much as 6 ft above ground level. One blaze was noted 8 ft above ground and the top of the tree had blown down, having broken off at the top of the blaze. This was a common occurrence and between Monuments 76 and 77 a 6-in. spruce tree, used as a bench mark, was also found broken off at the notch.

Monuments 77, 78 and 79 were found to be well constructed and at bench mark 112, northeast of Monument 78, a 6-in. tamarac was also found to be broken off at the notch.

Chainage—The distances between Monuments 77, 78 and 79 were chained and check-chained and were found satisfactory. Due to lakes and swamps, the distance between Monuments 76 and 77 could not be obtained by direct chainage but a satisfactory comparison was obtained by means of a local triangulation.

Azimuth—An azimuth observation was made at one of the triangulation stations and by calculation and angle measurements at Monuments 77 and 78, the azimuth of the three courses was determined. Two agreed within 3 and 6 seconds of arc respectively, and the third, a short course between Monuments 77 and 78, differed by 1 minute and 5 seconds from that of Mr. Roberts, which though apparently serious, would only amount to a lateral displacement of 0.36 link or less than 3 in. Monument 78, the terminal point of a 486-chain chord, fell in a very awkward position which might account for part of the discrepancy.

Inspection in Vicinity of Monument 1

From Monument 191 to Monument 1 the line passes through an old burn with no second growth and thence through mostly scrubby spruce timber. The line was cut about 8 ft wide and only five blazed trees were counted between these two monuments. Between Monuments 1 and 2, eight blazed trees were counted. The mounds at these monuments were well constructed. Bench marks 1 and 2 were found and consisted of 6-in. spikes in blazed 5-in. and 6-in. spruce trees respectively.

Chainage—The courses from Monuments 191 to 1 and Monuments 1 to 2 were both chained and check-chained and agreed with Mr. Roberts' values to well within the required tolerance of 1:13,200.

Azimuths—An azimuth observation was made at Monument 191 using Monument 2 as a reference object. Monument 1 was in perfect alignment and the azimuth of the two courses differed by 7 seconds of arc from that quoted by Mr. Roberts.

Inspection in Vicinity of Monument 90

Monument 90 is in the barren land but immediately east of the monument the line passed through a lightly timbered depression where traces of cutting were seen. However, the depth of the snow must have been considerable in the winter as the trees simply appeared to have been 'topped'.

No azimuth or distance measurements were made here. Levelling was done to check an indicated error of about 1 ft between Monuments 90 and 91. Almost absolute agreement was obtained between the main-level line run easterly and the check-level line in the reverse direction. These results substantiated the check-level values in the original survey.

Inspection in Vicinity of Monument 149

Posts and well-constructed mounds were found at Monuments 148, 149 and 150 although the mound at Monument 149 had sunk considerably into the swamp and was difficult to locate.

There are no trees in the vicinity of these monuments and no bench marks were found at any of the monuments or along the line between them.

Chainage—The distance between Monuments 148 and 149 was chained and check-chained and the results obtained agreed favourably with Mr. Roberts' distance for this course.

Azimuths—An azimuth observation was made on the line between Monuments 149 and 150 and the resulting azimuths for the courses Monuments 148–149 and 149–150 differed from those of Mr. Roberts by 9 and 1 seconds of arc respectively.

General Observations

The posts at all monuments were found to be securely set and were well marked. With the exception of two monuments, 78 and 149, all were located in excellent positions, generally on dry gravel ridges. The post at Monument 78, in a moss-covered boulder-filled depression, is liable to move as a result of frost action, while the post at Monument 149 is on a very flat, wet slope and may also be affected by frost.

Every monument visited was found to be visible from both adjacent monuments. The cut line in timber is clearly visible from the air. In the barren land it is impossible to trace the line from an aircraft or on the ground, but while flying along the line it is possible, by following the boundary map sheets, to identify almost all the mounds.

The following table shows a comparison of the results obtained:

Course	Azimuth				Distance			
	Roberts	Difference	Inspection	P.E.	Roberts	Difference	Inspection	Insp Accuracy
	° ′ ″		° ′ ″		Chains	Chains	Chains	
77–76	270 04 14	3″	270 04 11	±1″.5	118.7749	.0064 (1:18,500)	118.7685	Unchecked
78–77	270 04 27	1′05″	270 32 22		11.6019	.0006 (1:19,300)	11.6025	1:14,500
79–78	269 56 06	6″	269 56 00		34.0885	.0010 (1:34,000)	34.0875	1:42,600
191–1	89 55 27	7″	89 55 34	±1″.5	40.3585	.0004 (1:101,000)	40.3581	1:40,400
1–2	89 56 12	7″	89 56 19		73.9239	.0030 (1:24,600)	73.9209	1:35,200
149–148	270 03 42	9″	270 03 51	±0″.8	98.3835	.0022 (1:50,000)	98.3813	1:100,000
150–149	270 00 53	1″	270 00 54		132.8831	Not measured		

Random Comparisons

Departure from Astronomic Latitude 60°N

The boundary was surveyed as the theoretic parallel from a starting point established at astronomic latitude 60°N by a single astrofix. Before the survey was started this astrofix was verified as being a reasonable average of many other astrofixes along the north boundaries of Alberta and Saskatchewan. After the survey was completed the local astronomic latitude of the surveyed boundary was checked at Monument 100 and at Monument 171 by ties made to astrofix C-2 established by Corcoran in 1957 at Baralzon Lake and to the astrofix established by Ney in 1929 on the west coast of Hudson Bay. These astrofixes showed the latitudes of these two monuments to be 60°00′00″.21 and 59°59′58″.00 respectively. Both these values were well within the range of latitude anomalies that might have been expected due to local deviations of the plumb-line.

Comparisons with Mapping Control

Field parties of the Army Survey Establishment, Department of National Defence, made tellurometer traverses for mapping control in the vicinity of the boundary between 1959 and 1961. In this work ties were made to Monument 2 near the starting point of the boundary, to Monument 56 at Nueltin Lake and to Monument 171, the easterly terminal of the boundary. The relative positions of these monuments as determined through these traverses have been compared with those determined by the boundary dimensions and the discrepancies are tabulated below:

	Discrepancies		Total discrepancy as a ratio of length
	In Latitude	In Longitude	
Monument 2 – Monument 56	0″.12	0″.33	1 in 19,000
Monument 56 – Monument 171	0″.45	0″.17	1 in 20,000
Monument 2 – Monument 171	0″.33	0″.50	1 in 31,000

Level Check at Hudson Bay

The elevation of the water in Hudson Bay was determined at the end of the boundary at 14:37 C.S.T. on September 2, 1961. Based on B.M. 866H established by the Geodetic Survey of Canada near the 60th parallel at longitude 116°59′ and derived through about 768 miles of spirit levelling along the north boundaries of Alberta, Saskatchewan and Manitoba, this elevation was calculated to be 17.47 ft above mean sea level.

The water level at this time and place was calculated by the Dominion Hydrographer from tidal observations in Hudson Bay to be 5.5 ft ± 1 ft above mean sea level.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

Summary of Survey Results

The survey of the boundary between the province of Manitoba and the Northwest Territories has now been completed. It was started at the northeast corner of the province of Saskatchewan and was surveyed for a distance of 249 miles along the 60th parallel of astronomic latitude to the western shore of Hudson Bay.

On the boundary, 172 monuments have been erected, most of which are intervisible. The average interval between monuments is slightly under $1\frac{1}{2}$ miles. The maximum distance between monuments is 5.74 miles, viz. between Monuments 55 and 56 (Nueltin Lake) and the minimum distance is 0.06 mile between Monuments 5 and 6. The monuments are well-constructed and should provide good evidence of the position of the boundary for a long time. The cut line and blazed trees in the wooded portion should also provide evidence of the position of that portion for many years.

Atlas

The atlas which accompanies and forms part of this report comprises 15 map sheets. It forms a complete description of the boundary as surveyed.

Each atlas sheet covers 30 minutes of geographic longitude or about $17\frac{1}{3}$ miles of the boundary. The position and nature of each boundary monument is shown together with adjacent topographic detail.

The topographic detail is derived from the observations of the surveyor on the ground, supplemented by aerial photographs. In this way, the physical position of the boundary may be easily related to the natural features along it.

The spheroidal position of the boundary, as shown on the map sheets, is approximate and is derived from a Geodetic shoran station near Fort Smith in the Northwest Territories.

The ground profile of the boundary is also shown, plotted in such a way as to provide an appreciation of the nature of the terrain traversed by the boundary.

The locations of bench marks established during the survey, and their elevations, are shown on the profile, as are the elevations of the monuments. These elevations are derived from bench mark 866H (longitude 116°59′) established by the Geodetic Survey of Canada.

Recommendations

The Commission is confident that the surveys performed in the winters of 1958–59, 1959–60, 1961–62, and in September 1961, constitute adequate demarcation of the boundary between the province of Manitoba and the Northwest Territories and considers that the boundary should now be confirmed by appropriate legislation.

The Commission, therefore, recommends that:

1. The boundary between the Province of Manitoba and the Northwest Territories, defined on the ground by the Commission during the years 1959, 1960, 1961 and 1962, as shown on atlas map sheets 1 to 15 inclusive and signed by the respective Commissioners, be accepted as the boundary between the Province of Manitoba and the Northwest Territories.
2. The Legislature of the Province of Manitoba consent to declaration by the Parliament of Canada that the above-described boundary line is the true boundary between the Province of Manitoba and the Northwest Territories.
3. The Parliament of Canada so declare.

Past experience with other boundary lines has shown that no matter how well a line is marked on the ground, the original markings will ultimately disappear due to natural overgrowth or decay or to actual physical damage. Realizing the importance of preserving these ground markings, the Commission feels that provision should be made now for their preservation and restoration.

For this reason the Commission further recommends that:

4. The functions of the present Boundary Commission be extended to include the execution of such resurveys, line clearing and restoration work as may be necessary from time to time to maintain the present boundary vista and monuments in a good state of preservation and to establish any supplementary monuments that might be needed.
5. The present arrangement of sharing equally in the costs involved apply also to the foregoing functions.

Disposition of Survey Records

The surveyor's reports and the original records of his survey have all been filed in the Surveys Branch of the Department of Mines and Natural Resources at Winnipeg. Copies of the reports, plans and fair copy field notes have also been filed in the Canada Lands Survey Records at Ottawa.

Acknowledgements

The Commission wishes to record its appreciation to the Manitoba Government Air Service, the Canadian Army at Winnipeg and Fort Churchill, the Department of Transport, the Manitoba Department of Agriculture and other government and private agencies for the many courtesies and assistance extended by their officers to those of its survey parties.

The Commission also extends its thanks to the Geodetic Survey of Canada and to the Army Survey Establishment of the Department of National Defence for their help in providing field checks on some boundary dimensions.

A. C. Roberts, who was in charge of the major part of the field operation, and his various assistants all deserve considerable credit for having completed a difficult and sometimes dangerous task under very arduous conditions in a remote and barren district.

THE 60th PARALLEL OF LATITUDE

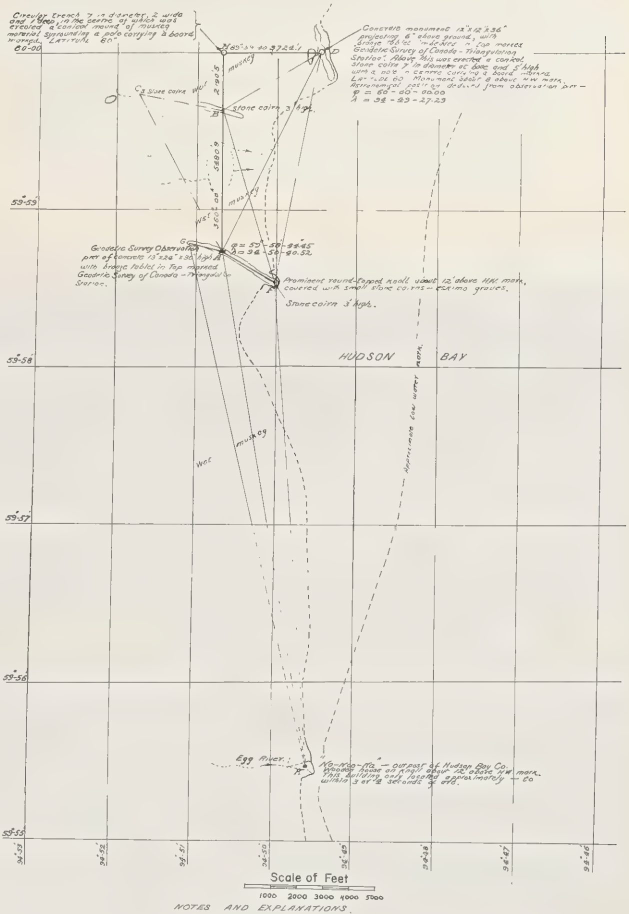
WHERE IT INTERSECTS

THE WEST COAST OF HUDSON BAY

Established in July 1929 by THE GEODETIC SURVEY OF CANADA

[signature]

Surveys Engineer.



NOTES AND EXPLANATIONS.

Transit line run from A to H and from H to D. Direct measurements checked by triangulation scheme.

Bearings referred to the meridian through A, are as follows :-

AB = 360-00-00"	FA = 301-17-00	GA = 105-03-30	BA = 180-00-00"	CB = 100-46-00"	DH = 269-59-40"
AD = 25-53-40	FB = 343-25-00	GF = 115-38-00	BC = 280-46-00	CA = 152-44-00	DF = 191-01-00
AF = 121-17-00	FD = 11-01-00	GK = 167-17-15	BH = 360-00-00		DA = 205-53-40
AG = 285-03-30	FK = 175-53-30	AK = 170-28-00	BD = 59-32-00	HB = 180-00-00	DB = 239-32-00
AC = 332-44-00	FG = 295-38-30		BF = 163-25-00	HD = 89-59-40	

Measured distances	AF = 2333.2	AG = 1253.6	BC = 3188.0	BH = 2190.5	HD = 3724.1
Calculated distances	AB = 5280.9	AC = 6836.2	AD = 8527.5	BD = 4320.5	BF = 6983.0
	DF = 9050.0	GF = 3554.4	GK = 20,639 ±	AK = 20,114 ±	FK = 18,677 ±

Gravel and boulder ridges 8 to 15 feet above H.W. mark are shown in brown

APPENDIX I

Station C-2 Baralzon Lake
Manitoba-N.W.T. Boundary

Co-ordinates of Marker: Latitude 60° 00′ 01″.23 ± 0″.07
Longitude 98 02 33.09

Description: This astronomic boundary station is located on a large island in Baralzon Lake which straddles the northern boundary of the province of Manitoba at approximately its mid-point. The station is located on high ground in the southern tip of the island.

Baralzon Lake lies just inside the barrens, and the ground in the vicinity of the station is covered with muskeg with some rocky outcrop. There is the odd dwarfed spruce along the water's edge.

On the easterly side of the tip of land there is an excellent sand beach for aircraft.

Station Marker: The station is marked by a standard 30-inch iron survey post inscribed C-2, 1957, driven into the ground. The top of the post extends about 1.5 feet above ground level. A 5-foot stone cairn was erected 2 feet south of the iron post. The cairn is located about 375 feet from the southern tip of the island along the easterly shore and about 17 feet from the edge of the bank.

Observations: The latitude was determined from 55 pairs of stars according to the Horrebow-Talcott method.

The longitude was determined from two sets of meridian transit observations. Time signals from radio station WWV were used.

Photographic Identification: Station C-2 on Baralzon Lake is pinpointed on high altitude aerial photograph A-12859-254.

G. A. CORCORAN
Geodetic Survey of Canada.

August 4, 1957.

Station S-10-C Hasbala Lake
Saskatchewan-N.W.T. Boundary

Co-ordinates of Marker: Latitude 59° 59′ 54″.64 ± 0″.06
Longitude 102 00 39.42

Description: This astronomic boundary station is located on the north end of Hasbala Lake which lies just south and west of the Manitoba-Saskatchewan corner.

The observing station is located on high ground north of the only sand beach at the north end of Hasbala Lake. A vista about 15 to 20 feet wide has been cleared from the westerly extremity of the beach in a northerly direction to the station marker.

Fire has recently destroyed most of the tree life for a considerable area around the station.

Station Marker: The station is marked by a standard survey iron post inscribed S-10-C, 1957, driven into the ground. The marker extends about 8 inches above the ground and is surmounted by burnt spruce poles wired together in the form of a tepee standing about 10 feet in height. The marker is in a rocky area about 900 feet in a northerly direction from the water along the N-S vista.

Observations: The latitude was determined from 43 pairs of stars according to the Horrebow-Talcott method.

The longitude was determined from three sets of meridian transit observations. Time signals from radio station WWV were used.

Photographic Identification: Station S-10-C on Hasbala Lake is pinpointed on high altitude aerial photographs A-14380V-39 and A-13217-42.

G. A. CORCORAN
Geodetic Survey of Canada.

August 15, 1957.

APPENDIX II

Summary of Monument Data

Monument No.	Description	Azimuth To Monument to West			Distance From Monument to West	Distance From Manitoba-Saskatchewan Boundary		Elevation Top of Post
		°	′	″	Chains	Miles	Chains	Feet
157	Aluminum Obelisk	—	—	—	—	0	0.00	
1	P. in rock S.M.	269	56	12	29.4338	0	29.4338	1167.99
2	P. in pipe S.M.	269	57	35	73.9239	1	23.3577	1220.92
3	P. in rock S.M.	269	59	35	106.0398	2	49.3975	1149.66
4	P. in rock S.M.	270	03	09	181.2982	4	70.6957	1348.17
5	P. in pipe S.M.	270	04	28	84.3796	5	75.0753	1356.39
6	P. in rock S.M.	269	55	15	4.8503	5	79.9256	1392.39
7	P. in rock S.M.	269	57	10	103.9454	7	23.8710	1435.98
8	P. in rock S.M.	269	59	18	111.2897	8	55.1607	1410.84
9	P. in rock S.M.	270	02	05	154.0579	10	49.2186	1345.12
10	P. in pipe S.M.	270	04	16	111.8567	12	1.0753	1335.34
11	P. in rock S.M.	269	55	53	20.7865	12	21.8618	1351.06
12	P. in rock S.M.	269	57	58	109.0253	13	50.8871	1366.46
13	P. in rock S.M.	270	01	51	206.4950	16	17.3821	1338.39
14	P. in rock S.M.	270	03	40	98.1877	17	35.5698	1351.00
15	P. in rock S.M.	270	04	41	51.5055	18	7.0753	1332.04
16	P. in rock S.M.	269	56	49	60.5513	18	67.6266	1378.32
17	P. in rock S.M.	269	59	11	127.9262	20	35.5528	1361.73
18	P. in rock S.M.	270	02	09	158.8153	22	34.3681	1374.55
19	P. in rock S.M.	270	03	24	68.3065	23	22.6746	1350.18
20	P. in pipe S.M.	270	04	40	70.4007	24	13.0753	1258.42
21	P. in rock S.M.	269	56	15	37.6306	24	50.7059	1264.89
22	P. in rock S.M.	270	01	09	262.9141	27	73.6200	1216.55
23	P. in rock S.M.	270	03	02	101.8600	29	15.4800	1192.92
24	P. in rock S.M.	270	04	33	74.0917	30	9.5717	1196.63
25	P. in pipe S.M.	270	04	45	9.5036	30	19.0753	1187.34
26	P. in rock S.M.	269	56	16	41.5873	30	60.6626	1219.07
27	P. in rock S.M.	269	57	50	84.2053	31	64.8679	1254.22
28	P. in rock S.M.	270	00	27	140.6065	33	45.4744	1303.70
29	P. in rock S.M.	270	01	26	51.9767	34	17.4511	1304.85
30	P. in rock S.M.	270	02	54	80.7969	35	18.2480	1299.56
31	P. in rock S.M.	270	03	12	103.5506	36	41.7986	1356.95
32	P. in rock S.M.	269	57	58	117.6583	37	79.4569	1273.75
33	P. in rock S.M.	270	02	03	213.8471	40	53.3040	1194.32
34	P. in rock S.M.	270	03	49	91.6820	41	64.9860	1136.35
35	P. in rock S.M.	270	01	24	79.7353	42	64.7213	1107.46
36	P. in rock S.M.	269	58	47	146.4867	44	51.2080	1248.69
37	P. in rock S.M.	270	01	49	161.9475	46	53.1555	1239.14
38	P. in rock S.M.	270	02	28	34.2083	47	7.3638	1233.45
39	P. in rock S.M.	270	03	39	63.7996	47	71.1634	1126.29
40	P. in rock S.M.	270	00	11	139.5442	49	50.7076	1136.82
41	P. in rock S.M.	269	57	56	40.8454	50	11.5530	1112.65
42	P. in rock S.M.	270	01	54	211.2751	52	62.8281	1087.86
43	P. in pipe S.M.	270	04	32	140.1972	54	43.0253	1144.02

APPENDIX II (*cont.*)

Monument No.	Description	Azimuth: To Monument to West			Distance: From Monument to West	Distance: From Manitoba-Saskatchewan Boundary		Elevation: Top of Post
		°	′	″	Chains	Miles	Chains	Feet
44	P. in rock S.M.	269	56	19	46.6087	55	9.6340	1152.20
45	P. in rock S.M.	269	59	17	158.1054	57	7.7394	1085.58
46	P. in rock S.M.	270	01	23	111.0487	58	38.7881	1053.36
47	P. in rock S.M.	270	03	35	117.6198	59	76.4079	1046.71
48	P. in pipe S.M.	270	04	36	52.6174	60	49.0253	1023.33
49	P. in rock S.M.	269	56	18	41.2621	61	10.2874	1073.06
50	P. in rock S.M.	270	00	06	195.2467	63	45.5341	1099.34
51	P. in rock S.M.	270	01	54	93.7798	64	59.3139	1089.20
52	P. in rock S.M.	270	04	31	134.0927	66	33.4066	1039.94
53	P. in rock S.M.	270	04	56	21.6187	66	55.0253	1008.39
54	P. in pipe S.M.	269	56	50	67.3388	67	42.3641	1014.37
55	P. in rock S.M.	269	58	13	74.5801	68	36.9442	938.01
56	P. in rock S.M.	270	04	37	459.5776	74	16.5218	944.61
57	P. in rock S.M.	270	02	13	241.3964	77	17.9182	969.82
58	P. in rock S.M.	270	02	34	222.5422	80	0.4604	983.89
59	P. in rock S.M.	270	00	22	165.5066	82	5.9670	1006.87
60	P. in rock S.M.	270	01	34	63.4441	82	69.4111	1051.55
61	P. in rock S.M.	270	04	24	147.0401	84	56.4512	1144.53
62	P. in rock S.M.	270	04	43	16.5741	84	73.0253	1116.96
63	P. in rock S.M.	269	57	39	102.0068	86	15.0321	1084.25
64	P. in rock S.M.	269	59	41	102.9893	87	38.0214	1078.72
65	P. in rock S.M.	270	02	41	153.9143	89	31.9357	1088.35
66	P. in rock S.M.	270	04	55	111.9234	90	63.8591	985.94
67	P. in rock S.M.	269	58	50	132.8663	92	36.7254	1048.52
68	P. in rock S.M.	270	01	11	184.0616	94	60.7870	1114.19
69	P. in rock S.M.	270	03	28	123.7179	96	24.5049	975.06
70	P. in pipe S.M.	270	01	31	103.0359	97	47.5408	954.15
71	P. in rock S.M.	270	00	08	213.1387	100	20.6795	1081.07
72	P. in rock S.M.	270	00	51	31.8351	100	52.5146	1090.92
73	P. in pipe S.M.	270	04	32	198.5107	103	11.0253	--
74	P. in rock S.M.	269	55	37	14.5616	103	25.5869	1076.73
75	P. in rock S.M.	269	59	10	188.9096	105	54.4965	1076.13
76	P. in rock S.M.	270	02	01	152.1520	107	46.6485	1070.14
77	P. in rock S.M.	270	04	14	118.7749	109	5.4234	1063.58
78	P. in rock S.M.	270	04	27	11.6019	109	17.0253	1032.70
79	P. in rock S.M.	269	56	06	34.0885	109	51.1138	1076.52
80	P. in rock S.M.	270	00	31	233.9588	112	45.0726	1064.47
81	P. in pipe S.M.	270	01	42	64.7697	113	29.8423	1043.91
82	P. in rock S.M.	270	04	34	153.1830	115	23.0253	1032.91
83	P. in rock S.M.	269	56	10	37.5567	115	60.5820	1038.18
84	P. in rock S.M.	269	57	35	75.7431	116	56.3251	1045.87
85	P. in rock S.M.	270	01	17	197.4743	119	13.7994	1082.97
86	P. in rock S.M.	270	02	56	87.5774	120	21.3768	1085.66
87	P. in pipe S.M.	270	04	35	87.6485	121	29.0253	1081.43
88	P. in rock S.M.	269	56	37	59.4187	122	8.4440	1085.40
89	P. in rock S.M.	269	59	53	174.1445	124	22.5885	1054.41

APPENDIX II (*cont.*)

Monument No.	Description	Azimuth To Monument to West			Distance From Monument to West	Distance From Manitoba-Saskatchewan Boundary		Elevation Top of Post
		°	′	″	Chains	Miles	Chains	Feet
90	P. in rock S.M.	270	01	56	106.9993	125	49.5878	1054.88
91	P. in rock S.M.	270	03	01	57.4537	126	27.0415	1041.08
92	P. in rock S.M.	270	02	28	133.2061	128	0.2476	1007.52
93	P. in rock S.M.	269	57	53	76.2319	128	76.4795	1022.92
94	P. in rock S.M.	269	59	23	77.5045	129	73.9840	1006.55
95	P. in rock S.M.	270	03	41	228.6000	132	62.5840	990.87
96	P. in rock S.M.	270	04	48	58.4413	133	41.0253	939.07
97	P. in rock S.M.	269	57	05	74.4660	134	35.4913	936.64
98	P. in rock S.M.	269	57	48	40.4512	134	75.9425	939.46
99	P. in pipe S.M.	269	59	17	80.7511	135	76.6936	915.2 (Ground)
100	P. in pipe S.M.	270	01	22	113.4362	137	30.1298	915.64
101	P. in rock S.M.	270	04	21	196.3265	139	66.4563	930.07
102	P. in rock S.M.	269	57	13	63.2352	140	49.6915	975.43
103	P. in rock S.M.	269	59	04	97.2457	141	66.9372	967.06
104	P. in rock S.M.	270	02	44	195.3599	144	22.2971	963.86
105	P. in rock S.M.	270	03	32	42.8941	144	65.1912	978.01
106	P. in rock S.M.	270	03	36	80.4308	145	65.6220	985.91
107	P. in rock S.M.	269	59	36	195.2527	148	20.8747	954.88
108	P. in rock S.M.	270	02	46	167.6703	150	28.5450	1015.65
109	P. in rock S.M.	270	04	09	72.5086	151	21.0536	1016.30
110	P. in rock S.M.	270	00	11	126.2098	152	67.2634	965.45
111	P. in rock S.M.	270	01	08	196.1536	155	23.4170	913.46
112	P. in pipe S.M.	270	04	50	211.1987	157	74.6157	862.20
113	P. in rock S.M.	269	58	51	152.5019	159	67.1176	887.36
114	P. in rock S.M.	270	00	50	106.3726	161	13.4902	920.70
115	P. in rock S.M.	270	02	43	102.0784	162	35.5686	881.21
116	P. in pipe S.M.	270	04	52	115.4567	163	71.0253	869.65
117	P. in rock S.M.	269	56	44	56.2436	164	47.2689	879.83
118	P. in rock S.M.	269	59	23	142.6317	166	29.9006	887.88
119	P. in rock S.M.	270	01	14	99.3670	167	49.2676	883.00
120	P. in rock S.M.	270	03	39	129.7186	169	18.9862	863.13
121	P. in pipe S.M.	270	04	43	58.0391	169	77.0253	845.76
122	P. in rock S.M.	269	58	39	166.1642	172	3.1895	848.76
123	P. in rock S.M.	269	59	18	36.2520	172	39.4415	845.0 (Ground)
124	P. in pipe S.M.	270	02	07	150.6201	174	30.0616	763.93
125	P. in pipe S.M.	270	04	36	132.9637	176	3.0253	673.0 (Ground)
126	P. in rock S.M.	269	56	37	61.1292	176	64.1545	695.13
127	P. in rock S.M.	269	59	44	166.4608	178	70.6153	701.77
128	P. in rock S.M.	270	02	35	153.1873	180	63.8026	728.13
129	P. in pipe S.M.	270	04	35	105.2227	182	9.0253	652.20
130	P. in pipe S.M.	269	56	25	48.4349	182	57.4602	629.73
131	P. in rock S.M.	270	00	37	221.7322	185	39.1924	615.52
132	P. in rock S.M.	270	02	42	110.7601	186	69.9525	671.52

APPENDIX II (*concl'd.*)

Monument No.	Description	Azimuth To Monument to West			Distance From Monument to West	Distance From Manitoba-Saskatchewan Boundary		Elevation Top of Post
		°	′	″	Chains	Miles	Chains	Feet
133	P. in rock S.M.	270	04	12	86.0796	187	76.0321	662.95
134	P. in rock S.M.	269	59	11	169.4769	190	5.5090	591.52
135	P. in rock S.M.	270	01	06	152.5102	191	78.0192	—
136	P. in rock S.M.	270	03	30	123.5738	193	41.5930	612.15
137	P. in pipe S.M.	270	04	42	59.4323	194	21.0253	631.0 (Ground)
138	P. in rock S.M.	269	57	11	80.2021	195	21.2274	614.36
139	P. in rock S.M.	270	00	03	152.6742	197	13.9016	557.77
140	P. in rock S.M.	270	04	09	218.9167	199	72.8183	525.60
141	P. in pipe S.M.	270	04	47	34.2070	200	27.0253	513.6 (Ground)
142	P. in rock S.M.	269	57	45	113.8578	201	60.8831	571.75
143	P. in rock S.M.	269	59	27	90.9756	202	71.8587	561.75
144	P. in rock S.M.	270	02	13	147.6877	204	59.5464	483.20
145	P. in pipe S.M.	270	04	43	133.4789	206	33.0253	491.3 (Ground)
146	P. in rock S.M.	269	56	30	47.2219	207	0.2472	557.58
147	P. in rock S.M.	269	59	03	135.7002	208	55.9474	562.14
148	P. in rock S.M.	270	01	52	149.8519	210	45.7993	532.44
149	P. in rock S.M.	270	03	42	98.3835	211	64.1828	466.72
150	P. in rock S.M.	270	00	53	132.8831	213	37.0659	474.94
151	P. in rock S.M.	270	00	50	203.3859	216	0.4518	481.04
152	P. in rock S.M.	270	04	38	204.5735	218	45.0253	410.07
153	P. in rock S.M.	269	57	58	131.4727	220	16.4980	393.52
154	P. in rock S.M.	270	01	02	164.4038	222	20.9018	361.74
155	P. in rock S.M.	270	03	41	140.7069	224	1.6087	350.46
156	P. in rock S.M.	270	04	36	49.4166	224	51.0253	324.4 (Ground)
157	P. in rock S.M.	269	58	24	154.2053	226	45.2306	327.92
158	P. in rock S.M.	270	02	05	195.2743	229	0.5049	305.37
159	P. in pipe S.M.	270	04	40	136.5204	230	57.0253	265.8 (Ground)
160	P. in rock S.M.	269	56	18	39.8589	231	16.8842	256.24
161	P. in rock S.M.	269	59	26	163.9369	233	20.8211	247.60
162	P. in rock S.M.	270	02	46	178.4960	235	39.3171	221.73
163	P. in rock S.M.	270	04	41	103.7082	236	63.0253	195.7 (Ground)
164	P. in rock S.M.	269	57	59	132.5192	238	35.5445	189.29
165	P. in rock S.M.	269	59	49	96.0755	239	51.6200	178.24
166	P. in rock S.M.	270	02	21	133.8416	241	25.4616	166.12
167	P. in rock S.M.	270	03	12	43.8031	241	69.2647	160.29
168	P. in rock S.M.	270	03	28	97.0922	243	6.3569	135.19
169	P. in rock S.M.	269	58	01	116.3737	244	42.7306	102.85
170	P. in rock S.M.	270	01	54	207.5066	247	10.2372	57.75
171	P. in pipe S.M.	270	04	44	150.7137	249	0.9509	34.51

NOTES: Initial Monument 157 marks the northwest corner of Manitoba.

Terminal Monument 171 is on the coast of Hudson Bay.

Elevations were obtained by spirit levelling from Bench Mark 442 (Elevation 1,164.18) established by W. V. Blackie, D.L.S., in 1958, near Monument 191 of the Saskatchewan-Northwest Territories Boundary. The elevation of this bench mark was derived by spirit levelling from Bench Mark 866H on the Mackenzie Highway (Longitude 116°59′), established by the Geodetic Survey of Canada and referred to the Canadian Geodetic Datum (mean sea level).

ABBREVIATIONS: P. in rock—Short Standard Boundary Post set in rock.

P. in pipe—Short Standard Boundary Post set in the top of a 4-foot length of 1½″ diameter iron pipe driven into the ground.

S.M. —Stone mound.

APPENDIX III

General Description of the Country

The country traversed by the boundary may be divided into two distinct sections, namely, forested land and barren land or tundra. The former extends from the northwest corner of Manitoba to a point about 103 miles east on the boundary where tree growth all but disappears. From this quite definite line of demarcation to the western shore of Hudson Bay, the boundary lies in the barren land. Descriptions of these two sections follow:

Northwest Corner of Manitoba to the Barren Land

Topography: This part of the boundary lies in forested country interspersed with numerous small lakes and swamps. Generally, the land is rolling but in places is quite hilly. Characteristic of this section are many eskers that are generally aligned northeast-southwest. Altogether ten eskers were crossed on this part of the line, and in their vicinity the country is very rugged. The tops of the eskers are quite narrow and are generally covered with gravel and boulders. Areas of fine sand frequently adjoin these eskers.

The line crosses few rivers of any size and only three large lakes, Charlie, Goose and Nueltin. The largest is Nueltin Lake, almost 100 miles long from north to south and containing many bays and islands.

Rock outcrops occur throughout this part of the boundary, and in many places large surface boulders are prevalent.

Starting at an elevation of approximately 1,150 ft above sea level at the western end of the boundary, the ground rises almost 290 ft in the first seven miles to reach its highest recorded elevation of 1,436 ft at Monument 7. From this point east to the edge of the barren land, the ground gradually falls to an elevation of 1,076 ft at Monument 74. The lowest elevation recorded on this part of the line was the water level on Hearne Bay of Nueltin Lake, which was 922 ft.

Forest Cover: The forest cover consists mainly of spruce on the higher land and tamarac in the swamps. Small stands of balsam fir, birch, and jackpine were found and in one place a few poplar were noticed on the line.

Spruce trees on the higher land averaged 4 to 6 in. diameter and were generally of stunted growth. On the slopes of an esker near Monument 36, however, many large spruce trees up to 18 in. diameter were noted.

The heaviest stand of spruce encountered was between Monuments 21 and 22 on the shore of a lake. The trees averaged only 2 in. diameter, but were about 15 ft high and grew so closely together that the trees cut on the line had to be placed along the edge of the line as they could not be forced through the growth on either side.

Tamarac trees in the swamps frequently reached a diameter of 8 in. although in one exceptional case, a 21-in.-diameter tree had to be cut on the line.

Minerals: No mineral occurrences were reported.

Game and Fur: Game and fur-bearing animals appeared to be scarce. The only animals seen were a few wolves and an Arctic fox, although on a few occasions, tracks of marten, otter, rabbit and ptarmigan were noticed. The surveyor met three trappers in this area; one was a resident of the area and the other two were Indians who had come north from Duck Lake in Manitoba

Across the Barren Land to Hudson Bay

Topography: Most of this part of the boundary passes through gently rolling country with the last 20 miles towards Hudson Bay being quite flat. The low-lying areas are swampy while the higher ground is covered with sand, gravel and boulders. Two eskers were crossed in this portion of the line.

From Monument 151 to Monument 158 a slightly different type of country was encountered. Piles of rocks and boulders stretched everywhere for miles and in the low-lying areas, the rocks are

boulders often protruded from water. This area extended north and south of the line as far as the eye could see and proved to be a real obstacle to ground transportation.

After crossing this 'rock pile' the country sloped gently towards Hudson Bay and gradually flattened out so that it was impossible to tell in winter whether one was standing on lake or tundra without digging to check for ice. The coast of Hudson Bay is flat and swampy and the shore itself is a boulder-strewn mud flat.

Numerous lakes are crossed by the boundary, the largest being Baralzon Lake. The water in the lakes is generally clear until the line approaches Hudson Bay where the lakes are shallow and swampy. There was no indication of fish in any of the lakes, but enquiries at Churchill revealed that there are fish in Baralzon and some other large lakes.

Only three rock outcrops were noted on this part of the boundary.

Across the barren land the ground slopes gently at an average rate of about 7 ft per mile to Hudson Bay. The recorded elevation of the ice on Baralzon Lake was 905 ft.

Forest Cover: There is almost no tree growth of any size in this area apart from a few small stands of spruce and tamarac in the lee of bluffs. Between Monuments 117 and 128 there is a total of about 3,000 ft of cutting on the line but this is the only part of the boundary in the barren land visible as a cut line. In the 'rock pile' area, a few stunted spruce about 3 ft in height were noticed.

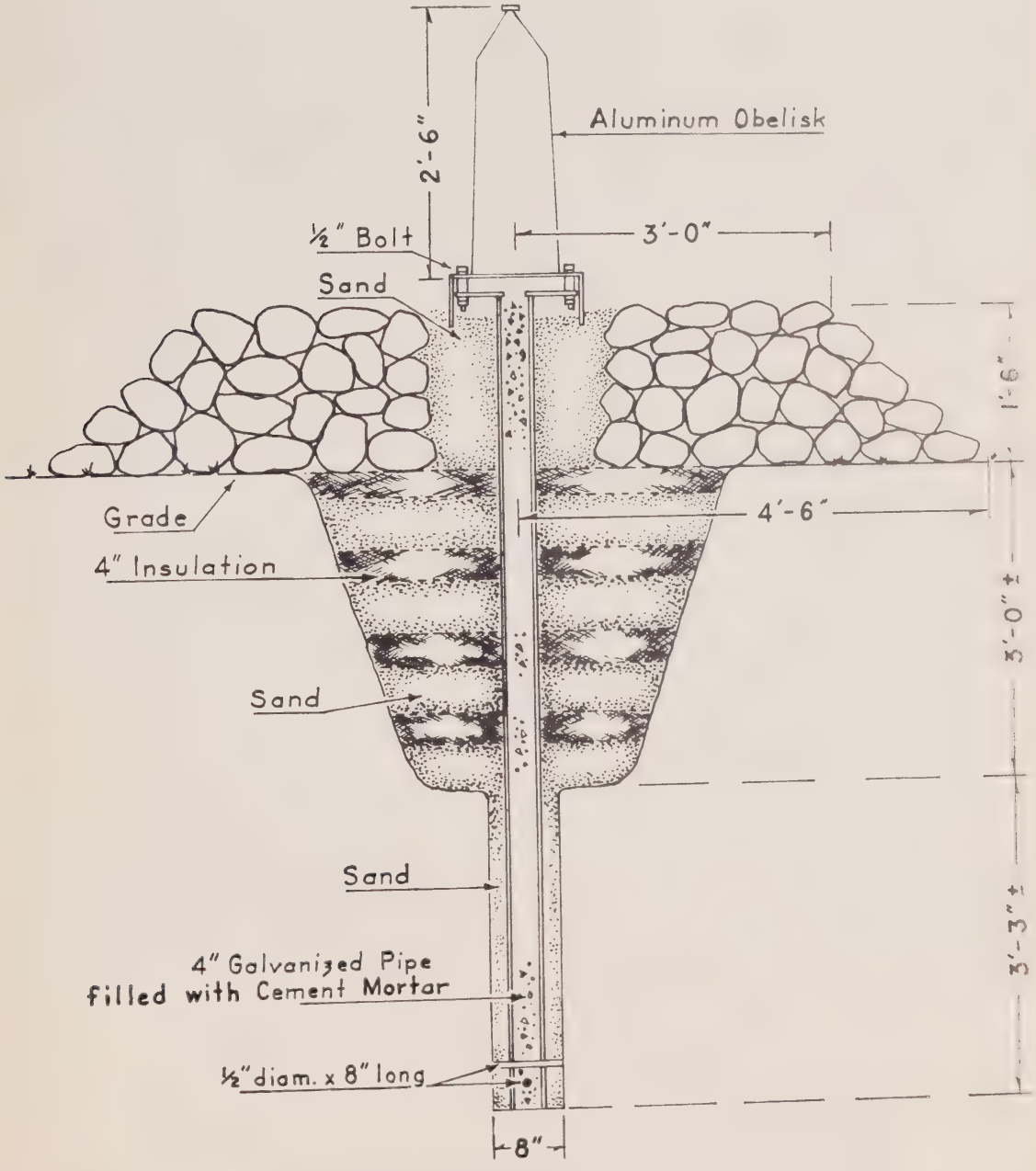
Game and Fur: The only animals seen on the barren land part of the boundary were one caribou, two wolves and three or four Arctic foxes. Tracks of lemmings were noticed and near Hudson Bay, the tracks of a polar bear were seen.

No trappers or signs of trapping were observed on this part of the boundary.

APPENDIX IV

Description of Special Monument at the Northwest Corner of the Province of Manitoba

This monument consists of a 4-in.-diameter, grout-filled galvanized iron pipe, 8 ft long, set in the ground to a depth of 6 ft. The pipe is anchored at the lower end with two steel rods, 8 in. long placed through holes in the pipe and on its upper end there is welded a steel plate or flange, 14 in. square. Attached by bolts to the steel plate is a hollow aluminum obelisk, $2\frac{1}{2}$ ft high, 10 in. square at the base and with a 3-in.-diameter cap welded to the top of the obelisk. On the four sides of the obelisk are sandblasted the words: Manitoba, Saskatchewan, Northwest Territories and Manitoba-Saskatchewan Boundary Commission 1962, respectively.



Sketch of monument at northwest corner of Manitoba.

*Erected under instructions of Manitoba-Saskatchewan Boundary Commission, 1962.

The aluminum obelisk has an opening on its under-side to permit the insertion of material of historic nature. When placing the monument the surveyor inserted a glass container containing names of the members of the survey party, date of erection and other pertinent information.

Around the pipe at its lower end, sand was placed to within 3 ft of ground level and from this point to ground level, alternate layers of sand and Zonolite insulation were placed. To complete the monument, a square base, rising $1\frac{1}{2}$ ft above ground, was erected from field stones, as shown in the diagram.

Photo of monument at northwest corner of Manitoba, looking south.

APPENDIX V

Photographs of Typical Monuments

Monument 8

Monument 24

Monument 29

Monument 77

Monument 121

Monument 169

Monument 171